OPERATION & MAINTENANCE HANDBOOK

MODEL 101
PULSE GENERATOR
Part Number 37000-424

INSTRUMENT REGISTRY

SYSTRON-DONNER CORPORATION

DATAPULSE

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MODEL 101 PULSE GENERATOR

The Datapulse Model 101 is an economical high performance pulse generator designed for a broad range of laboratory test applications. The reduced complexity of the unique solid state circuits combines reliable operation with versatile performance in a conveniently compact package. The simultaneous positive and negative outputs deliver 2 watts into 50 ohms. Pulse amplitude, width, delay and repetition rate are continuously variable. Other capabilities include single or double pulse operation, external triggering synchronous or asynchronous gating, reference trigger outputs, sine wave triggering, and manual single pulse operation.

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SECTION I

SPECIFICATIONS

1.1 REPETITION RATE

Repetition rate is continuously variable from 10 hertz to 10 megahertz in six decade ranges for either single or double pulse operation. Effective rates to 20 megahertz may be set up in the double pulse mode.

1.2 EXTERNAL TRIGGER

The external trigger input is ac coupled and operates at 0 to 10 megahertz from ±0.25 volt pulses with a minimum duration of 20 nanoseconds, or 50 hertz to 10 megahertz from 1 volt rms sine waves. Slope polarity and level controls provide triggering at any point on the input waveform more than 0.25 volts and less than 5 volts above or below the average dc level. Input impedance is greater than 2.5 k ohms. The maximum transient amplitude which may be safely applied is ±5 volts.

1.3 MANUAL CYCLING

In the single pulse mode, actuating the single pulse pushbutton provides one cycle of output (single or double pulse mode).

1.4 GATED OPERATION

The gating mode is selected as nongated (continuous), synchronously gated, or asynchronously gated. Signal levels more positive than +2 volts are required to enable the outputs in either gated mode. The maximum level which may be safely applied is 10 volts.

1.4.1 Synchronous Gating

The repetition rate oscillator is normally off in this mode and is turned on for the duration of an applied gate pulse. Both main outputs and both trigger outputs are gated and synchronized to the gate signal.

1.4.2 Asynchronous Gating

The pulse delay circuit is gated in this mode and the rate oscillator operates continuously. Main pulse outputs and the reference trigger begin with the first cycle (internally or externally triggered) after the gate pulse occurs and stop when the gate pulse subsides. The advanced trigger is not gated and occurs at the oscillator repetition rate.

1.5 TRIGGER OUTPUTS

1.5.1 Advanced Trigger

The advanced trigger is a positive pulse with a minimum amplitude of 1.7 volts from a 50 ohm source, and is typically 15 nanoseconds in duration. Available on internally triggered operations only, the advance trigger occurs approximately 10% of the repetition rate period before the reference trigger.

1.5.2 Reference Trigger

The reference trigger is a positive pulse with a minimum amplitude of 2.0 volts from a 50 ohm source, and is typically 15 nanoseconds in duration. When triggered from an external source, the reference trigger occurs approximately 30 nanoseconds after the external trigger.

1.6 PULSE MODE

Single or double pulse operation is selected by the pulse mode switch.

1.6.1 Single Pulse

One pulse per cycle occurs in the main outputs at the end of the delay period.

1.6.2 Double Pulse

Two identical pulses per cycle occur in the main outputs, the first approximately 40 nanoseconds after the reference trigger and the second at a time determined by the pulse delay controls.

1.7 PULSE DELAY

Pulse delay is continuously variable from 40 nanoseconds with respect to the reference trigger, or 60 nanoseconds with respect to an external trigger, up to a maximum of 10 milliseconds in six decade ranges. Delay is variable over at least 70% of the pulse period up to a repetition rate of 1 megahertz, decreasing to 50% above 4 megahertz and 30% at 10 megahertz. The reference trigger is counted down when the delay is greater than the pulse period, with stable countdown ratios greater than 100:1 possible; the advance trigger is not counted down.

1.8 PULSE WIDTH

Pulse width is continuously variable (measured at the 50% point of the leading and trailing edges) from typically 35 nanoseconds (40 nanoseconds maximum) to 10 milliseconds in six decade ranges. The maximum duty cycle is at least 60% and is typically 70%.

1.9 MAIN PULSE OUTPUT

Pulse amplitude is continuously variable from 0.5 to 10 volts into 50 ohms with simultaneous positive and negative dc coupled outputs (baselines are at ground). The source impedance decreases with amplitude and is approximately 50 ohms at amplitudes less than 5 volts.

1.10 RISE and FALL TIME

Rise time is less than 5 nanoseconds, and fall time is typically less than 7 nanoseconds (10 nanoseconds maximum) with the outputs terminated in 50 ohm resistive loads.

1.11 JITTER

Repetition rate, delay, and width jitter are less than 0.15% (typically 0.1%) on each range (within the highest decade on the width and delay ranges with more than 10:1 coverage).

1.12 WAVEFORM ABERRATION

Overshoot, preshoot, ringing, and top slope aberration are typically less than ±5% (with a maximum of ±7%) at amplitudes greater than 3 volts (with a properly connected 50 ohm terminations).

1.13 OUTPUT PROTECTION

Output stages will not be damaged by any combination of front panel control settings and will withstand short circuits to ground of any duration. The instrument is not rated for operation into loads at other than ground potential.

1.14 OUTPUT MIXING

Same polarity outputs may be diode mixed with a negligible loss of amplitude. Same or opposite polarity outputs may be resistor mixed with a resultant loss of amplitude. Outputs may not be directly coupled together.

1.15 OPERATING TEMPERATURE

The instrument is designed for operation in ambient temperatures of 0^{o} to 50^{o} C (32^{o} to 122^{o} F).

1.16 POWER REQUIRED

Approximately 15 watts at 105–125/210–230 volts and 50–400 hertz ac is required. All power supplies are regulated against line and load changes.

1.17 PHYSICAL CHARACTERISTICS

Instrument weight is approximately 8 pounds. Dimensions are 3½" H x 8½" W x 11" D. Each instrument is furnished with an attached line cord and NEMA 3-prong plug. The cabinet and front panel are brushed aluminum with black etched markings and trim. The russet brown top,

bottom, and side panels are removable. A tilt-up bracket is provided. Instruments may be rack mounted by Type 1005 (single unit) or Type 1006 (dual unit) Rack Mounting Sets.

1.18 ACCESSORIES AVAILABLE (Figure 1-1)

1.18.1 Type 1005 Rack Mounting Set

This set mounts a single instrument in a standard 19 inch wide by 3½ inch high rack panel, offset to either side of center.

1.18.2 Type 1006 Rack Mounting Set

This set mounts two instruments in a standard 19 inch wide by 3½ inch high rack panel.

1.18.3 Type 2003A 50 Ohm Termination

This specially designed load provides proper termination of 50 ohm coaxial cables for fast-rise pulse outputs.

1.18.4 Type 2101 Inverting Transformer

The 2101 transformer inverts the positive trigger output (advanced or reference) for applications requiring a negative synchronous trigger.

1.18.5 Type 2302 Mixing Unit

The mixing unit combines two same polarity outputs with approximately 1 volt loss of amplitude.

1.18.6 Type 2401 Variable Integrator

This accessory provides a means of varying pulse rise and fall times.

1.18.7 Instruction Manual

One operation and maintenance handbook is supplied with each instrument. Additional handbooks are available at a slight additional charge.

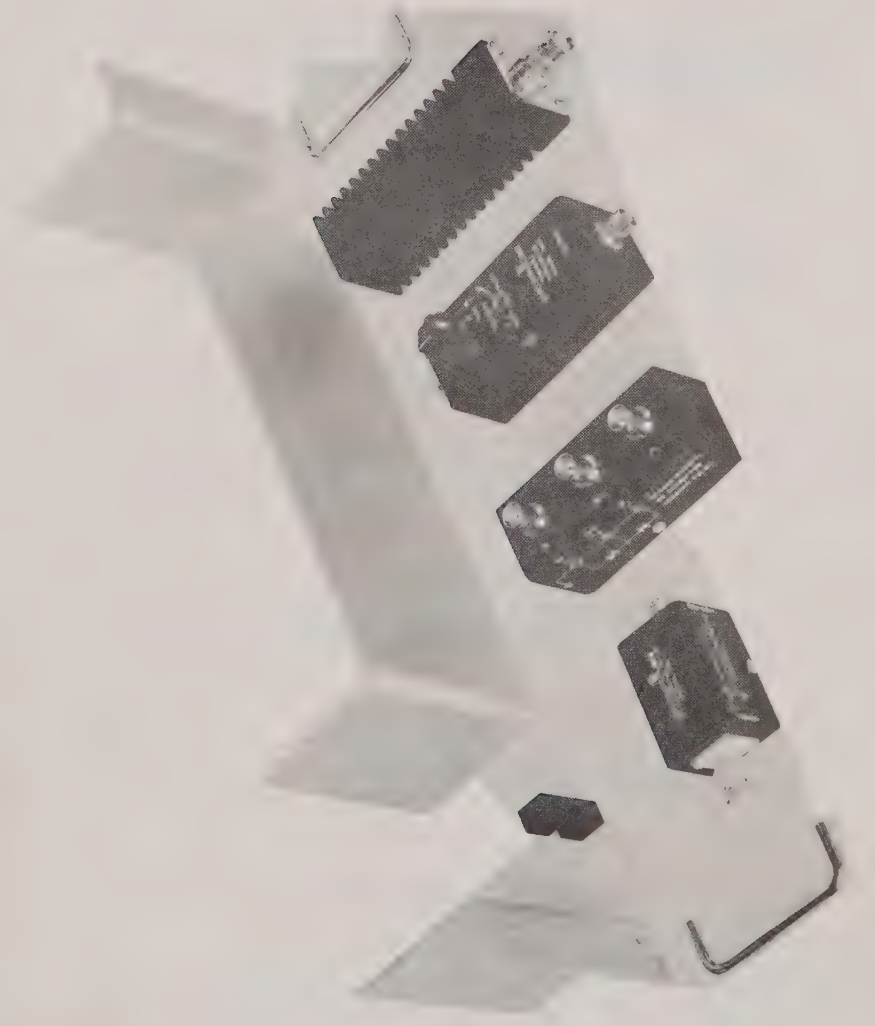


Figure 1-1. Model 101 Accessories

SECTION II

OPERATION

2.1 GENERAL INFORMATION

CAUTION

The outputs are designed for 50 ohm resistive loads. An inductive load or active circuit connected directly to an output may damage the instrument. Refer to paragraph 2.4 (Operating Instructions) for non-standard load connection and output mixing information.

Pulse amplitude, width, delay, and repetition rate are continuously variable over broad ranges, and provide an infinite variety of pulse parameter combinations to satisfy many test requirements. Single or double pulse operation, simultaneous positive and negative outputs, flexible external gating and triggering, and countdown capabilities extend the instrument's versatility. Extra operating convenience is gained through 1000:1 vernier control of pulse width and delay. Available accessories provide variable rise and fall times, reference trigger inversion, low loss output mixing and minimum distortion load termination.

Gating capabilities consist of synchronous, asynchronous and coincidence gating. The output pulse train is synchronized to the leading edge of an externally applied gate waveform in the synchronous mode. In the asynchronous mode, the output pulse train begins with the first advance trigger after the gate pulse occurs and continues until the gate pulse subsides; the output is quiescently off between gate pulses while the rate oscillator continuously provides advance trigger outputs. The reference trigger is gated in both modes while the advance trigger is gated in the synchronous mode only. Coincidence gating is achieved by application of both a gate signal and an external trigger pulse so that output pulses occur only when the two are coincident.

Frequency division by synchronous countdown is obtained from either internal or external triggering when the delay is set greater than the trigger period and the output pulse is a subharmonic of the trigger rate. The reference trigger occurs at the subharmonic rate in either case while the advanced trigger occurs at the oscillator rate for internal triggering and is turned off for external triggering.

2.2 CONTROLS and CONNECTORS (Figure 2-1)

2.2.1 Power Switch

The POWER switch connects ac power to the transformer primary and lights the pilot lamp when the switch is turned ON.

2.2.2 Repetition Rate

The REPETITION RATE rotary switch selects either the triggered mode, or the repetition rate range for internally triggered operation. The smaller vernier knob provides continuously variable control of all ranges. There are six decade ranges and the instrument is set to the rate indicated on the front panel when the vernier is fully clockwise.

The SINGLE PULSE position permits the instrument to be triggered manually for one cycle of output by the SINGLE PULSE pushbutton.

The EXT TRIG SLOPE (+) and (-) positions permit the instrument to be triggered from an external source by either a positive or negative going waveform.

In the LINE SLOPE positions the instrument is triggered from either the positive or negative going slope of the ac line voltage waveform.

The TRIGGERING LEVEL control determines the (+) or (-) amplitude of a signal that will trigger the instrument for either external or line voltage triggering.

A BNC connector is provided for the external TRIGGER INPUT.

2.2.3 Pulse Delay

The PULSE DELAY rotary switch selects one of six decade ranges and the smaller vernier knob provides continuously variable control of each range. The instrument is set to the delay indicated on the front panel when the vernier is fully clockwise.

NOTE: Vernier control of delay and width should be limited to a single range step. Pulse distortion may occur if too much vernier control is used. Also the outputs may become unstable because recovery time is longer for higher ranges.

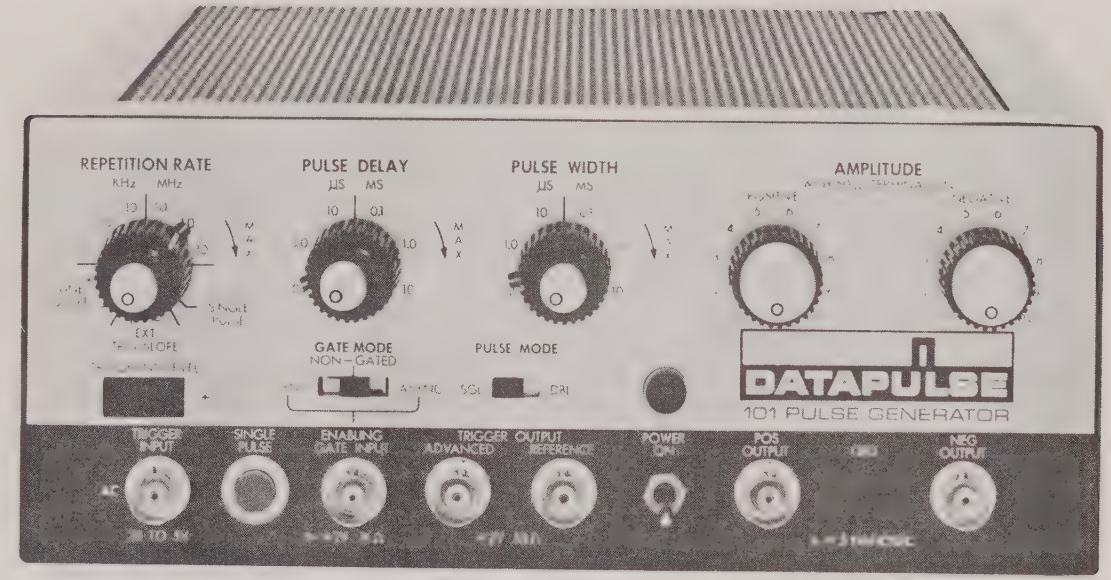


Figure 2-1a. Model 101 Controls and Connectors

Figure 2-1b. Model 101 Controls and Connectors

2.2.4 Pulse Width

The PULSE WIDTH rotary switch selects one of six decade ranges and the smaller vernier knob provides continuously variable control of each range. The instrument is set to the width indicated on the front panel when the vernier is fully clockwise.

2.2.5 Amplitude

The POSITIVE and NEGATIVE pulse AMPLITUDE knobs provide continuously variable amplitude control of the simultaneously occurring main outputs. The baseline for both outputs is at ground potential.

The POS OUTPUT and NEG OUTPUT BNC connectors couple the main outputs to external loads. The GRD jack provides access to the instrument ground for test connections.

2.2.6 Gate Mode

The main outputs are continuous when the GATE MODE switch is in the NON-GATED position but are interrupted and occur in gated bursts, as controlled by an externally applied gate signal when the switch is in either the SYNC or the ASYNC position.

In the SYNC position, the repetition rate oscillator is disabled and the main output pulses occur only during the pulse interval of an applied gate signal. The first main pulse of a gated burst is synchronized to the leading edge of the gate pulse and both trigger outputs are gated.

The pulse delay circuit rather than the repetition rate oscillator is disabled in the ASYNC position, and on internally triggered operations the advance trigger is available as a clock pulse. Main output and reference trigger pulses begin with the first rate oscillator pulse after the start of a gate pulse and continue until the gate pulse subsides, for either internal or external triggering.

The external gate signal is connected to the ENABLING GATE INPUT BNC connector.

2.2.7 Pulse Mode

Single or double pulse operation is selected by the PULSE MODE switch. In the SGL position, one pulse per cycle occurs at the out-

puts, delayed from the reference trigger for a period set by the delay controls. Two identical pulses occur when the switch is in the DBL position, the first is delayed approximately 30 nanoseconds from the reference trigger, and the second is delayed for a period determined by the delay controls.

2.2.8 Trigger Output

The TRIGGER OUTPUT BNC connectors couple the ADVANCE and REFERENCE trigger outputs to external instruments.

2.2.9 Power Input

A 8-foot, 3-wire ac line cord with a NEMA 3-prong plug is attached to the back of the instrument.

The 115/230 selector switch on the back panel connects the power transformer primaries for operation from either a 115 or a 230 volt ac input.

Overload protection is provided by a ½ ampere cartridge type fuse mounted on the back panel.

2.3 FUNCTIONAL VERIFICATION

The following procedure provides a brief check of the instrument and an introduction to the controls.

CAUTION

The outputs are designed for 50 ohm resistive loads. An inductive load or active circuit connected directly to an output may damage the instrument. Refer to paragraph 2.4 (Operating Instructions) for non-standard load connection and output mixing information.

2.3.1 Equipment (or equivalent) Required

a. A general purpose oscilloscope of at least 15 megahertz bandpass with triggered sweep.

NOTE: The general purpose oscilloscope is adequate for the basic tests outlined here but a sampling oscilloscope is needed

for a full range check to verify specifications. Coaxial attenuators for the main pulse and trigger outputs may also be required because many sampling oscilloscopes are limited to inputs below 250 millivolts.

b. A 50 ohm coaxial termination capable of 2 watts dissipation such as a Datapulse 2003A Power Termination.

NOTE: A one watt termination is adequate for most combinations of control settings but should be used with care because pulse output power approaches 2 watts for high duty cycle waveforms at full amplitude.

c. A 50 ohm coaxial termination with BNC connectors capable of ½ watt dissipation.

d. A general purpose signal generator capable of 2 volts into 500 ohms (the square wave amplitude calibrator of many oscilloscopes may be adequate).

e. Three 50 ohm coaxial cables (3 to 4 feet long) with BNC connectors, and one BNC Tee connector.

2.3.2 Test Connections and Settings

CAUTION

Check the position of the 115/230 volt slide switch on the back panel for agreement with the line voltage before connecting the power cord.

a. Connect the instrument to a suitable power source.

b. Connect a 50 ohm coaxial cable from the POS OUTPUT to the oscilloscope input and terminate the cable at the oscilloscope using the 50 ohm (2 watt) coaxial termination and the BNC Tee connector.

c. Connect a 50 ohm cable from the REFERENCE TRIGGER OUTPUT to the oscilloscope trigger input, and terminate the cable in 50 ohms at the oscilloscope using the ½ watt termination.

d. Set the instrument controls as follows:

Control	Setting
POWER switch	off
REPETITION RATE range	1.0 MHz
REPETITION RATE vernier	midrange
PULSE DELAY range	1.0 μs
PULSE DELAY vernier	midrange
PULSE WIDTH range	1.0 μs
PULSE WIDTH vernier	fully clockwise
POSITIVE AMPLITUDE	5 V
NEGATIVE AMPLITUDE	5 V
GATE MODE switch	NON-GATED
PULSE MODE switch	SGL

e. Set the oscilloscope sweep speed to 0.2 μs/cm and the vertical sensitivity to 2 V/cm.

2.3.3 Main Pulse Output

a. Turn the POWER switch ON. Note that the pilot lamp goes on and a rectangular pulse (approximately 5 volts high and 1 microsecond wide with a flat top and near vertical leading and trailing edges) appears on the oscilloscope trace.

b. Turn the POSITIVE AMPLITUDE control in both directions and verify that the amplitude decreases to 3 volts and increases to 10 volts uniformly without any noticeable effect on waveshape. Return the amplitude control to the 5 volt position.

c. Disconnect the coaxial cable from the POS OUTPUT and reconnect the cable to the NEG OUTPUT. Note that the negative output looks like the positive output inverted.

d. Repeat step (b) for the NEGATIVE AMPLITUDE control. Reconnect the POS OUTPUT to the oscilloscope input.

e. Turn the PULSE WIDTH vernier counterclockwise. Note that the pulse width follows the control and decreases smoothly. Turn the vernier to the fully clockwise position.

f. Turn the PULSE DELAY vernier in both directions and note that the pulse follows the controls, moving smoothly to the left and to the right. Return the vernier to the minimum position.

g. Turn the PULSE WIDTH selector to 0.1 μs and the REPETITION RATE selector to 10 MHz. Note that two or three pulses appear on the oscilloscope, and that the number of pulses increases when the REPETITION RATE vernier is turned clockwise.

2.3.4 Double Pulse Mode

a. Retain the test connections of paragraph 2.3.2 and set the oscilloscope sweep speed to 1.0 μs/cm.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE range	0.1 MHz
REPETITION RATE vernier	fully clockwise
PULSE DELAY range	10 μs
PULSE DELAY vernier	fully counterclockwise
PULSE WIDTH range	1.0 μs
PULSE WIDTH vernier	fully clockwise
POSITIVE AMPLITUDE	5 V
NEGATIVE AMPLITUDE	any position
GATE MODE switch	NON-GATED
PULSE MODE switch	DBL

c. Turn the PULSE DELAY vernier clockwise and note that a second pulse appears on the oscilloscope trace moving smoothly from left to right, following the control.

2.3.5 Single Pulse Operation

a. Retain the test connections of paragraph 2.3.2 and set the oscilloscope sweep speed to 1.0 ms/cm.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE range	SINGLE PULSE
PULSE DELAY range	1.0 MS
PULSE DELAY vernier	fully clockwise
PULSE WIDTH range	1.0 MS
PULSE WIDTH vernier	midrange
POSITIVE AMPLITUDE	5 V
GATE MODE switch	NON-GATED
PULSE MODE switch	SGL
Remaining controls	any position

c. Press the SINGLE PULSE pushbutton and verify that one pulse (only) appears on the oscilloscope trace each time the button is actuated.

2.3.6 External and Line Slope Triggering

a. Retain the test connections of the previous paragraph (2.3.5) and set the oscilloscope sweep speed to 0.5 ms/cm.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE range	(+) EXT TRIG SLOPE
PULSE DELAY range	1 MS
PULSE DELAY vernier	fully counterclockwise
PULSE WIDTH range	1 MS
PULSE WIDTH vernier	midrange
POSITIVE AMPLITUDE	5 V
GATE MODE switch	NON-GATED
PULSE MODE switch	SGL
Remaining controls	any position

c. Connect either the signal generator or the output of the oscilloscope amplitude calibrator to the TRIGGER INPUT jack. If the calibrator is used, set the amplitude to 1.0 volt (the frequency is fixed at 1 kHz). When a signal generator is used, adjust the frequency to 1 kHz and set the amplitude to 2 volts.

d. Adjust the TRIGGERING LEVEL control until several (approximately 5) pulses appear on the oscilloscope trace. Switch the REPETITION RATE selector to (-) EXT TRIG SLOPE and verify that the pulses do not disappear (the trigger input is capacitor coupled).

e. Turn the REPETITION RATE selector to (-) LINE SLOPE, the PULSE WIDTH selector to 10 ms and the oscilloscope sweep speed to 5 ms/cm.

f. Adjust the TRIGGERING LEVEL control until several (3 or 4) pulses appear. Switch the REPETITION RATE selector to (+) LINE SLOPE and note that the pulses do not disappear.

2.3.7 External Gating

a. Retain the test connections of the previous paragraph (2.3.6) except connect the output of the amplitude calibrator (or the signal generator) to the ENABLING GATE INPUT and trigger the oscilloscope from the gate signal. Set the oscilloscope sweep speed to 0.5 ms/cm.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE range	0.1 MHz
REPETITION RATE vernier	fully counterclockwise
PULSE DELAY range	0.1 MS
PULSE DELAY vernier	fully counterclockwise
PULSE WIDTH range	0.1 MS
PULSE WIDTH vernier	midrange

Control	Setting
POSITIVE AMPLITUDE	5 V
GATE MODE switch	SYNC
PULSE MODE switch	SGL
Remaining controls	any position

c. Verify that the pulses occur in gated bursts. Turn the GATE MODE switch to the NON-GATED position and note that the pulse output is continuous. Switch to the ASYNC position and note that the output is gated but unstable.

NOTE: The output appears unstable in the asynchronous mode because the instrument repetition rate oscillator operates continuously and is not synchronized to the gate signal nor the oscilloscope.

2.4 OPERATING INSTRUCTIONS

2.4.1 Idle Output

When only one output is being used, radiation from the other output may cause ringing of the output in use. This can be conveniently avoided by reducing the amplitude of the idle output to a low voltage so that the output is terminated in 50 ohms by the attenuator.

2.4.2 Output Termination

Fifty ohms is used for the output impedance because of the wide use and availability of 50 ohm cables, connectors, and accessories. To get clean wave shapes with fast transition time, both the interconnecting cable and the load termination must have an impedance of 50 ohms. The terminating impedance must not vary more than ±5% if instrument specifications are to be met. Proper loading is conveniently obtained by using a Datapulse 2003A Power Termination which also eliminates the need to limit pulse amplitude and duty cycle.

2.4.3 Output Cabling

When the pulse generator is connected to a load that is several feet away, clean waveforms with low distortion are maintained

by using a 50 ohm coaxial cable terminated in 50 ohms at the load rather than at the instrument. Terminating at the pulse generator, using clip leads, or using coaxial cable with the wrong characteristic impedance will have the same pulse distorting effect as terminating in the wrong impedance.

2.4.4 Nonlinear Loads

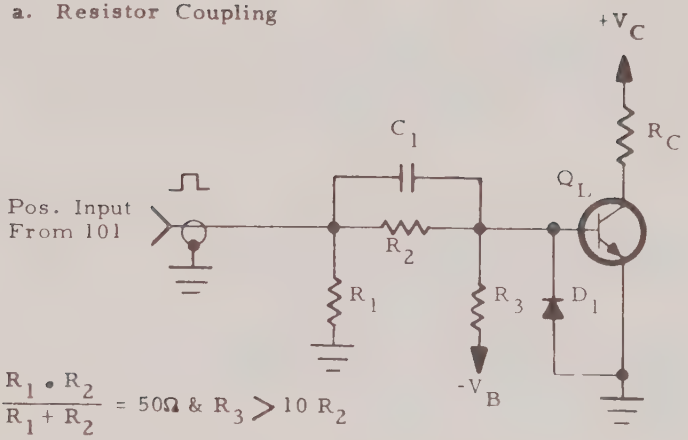
Operating directly into nonlinear devices such as transistors and diodes that exhibit high impedance in one direction and low impedance in the other causes waveform distortion. This can be prevented by terminating the pulse generator in a network that reflects uniform loading in both directions. Two methods for driving the base of a transistor, or operating into a diode (the base-emitter junction of a transistor resembles a diode) are illustrated in Figure 2-2. In the resistor coupled network, transistor Q_L is biased off between pulses and is turned on during the pulse interval, while in the capacitor coupled circuit Q_L is quiescently on and is turned off by the applied pulse.

Values for resistors R_1, R_2, and R_3 and capacitor C_1 depend primarily on the transistor characteristics in both circuits. R_1 is calculated from the equations given in the figure to provide proper termination for the pulse generator (50 ohms) and prevent ringing. C_2, in the capacitor coupled network, depends on pulse width and repetition rate, and is determined by the given equations. For a PNP transistor, the polarity of the input pulse, the applied voltage, and the diode are reversed. In both networks, load mismatch and waveform distortion are more pronounced at fast rise and fall times.

2.4.5 Output Decoupling

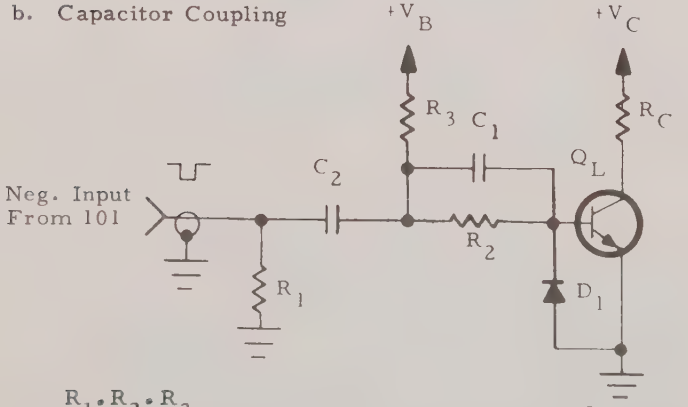
An emitter follower may be used to decouple the output from a nonlinear load when the passive networks of Figure 2-2 are unsuitable. The circuits of Figure 2-3 are useful, for example, when more power is required than can be obtained from either the resistor or the capacitor coupled circuit. The transistor selected must have enough power and gain to meet load requirements and should have high frequency response characteristics with low capacity input for fast transition times and minimum pulse distortion. The 22 ohm resistor in the output is a parasitic suppressor that reduces pulse aberrations. The value of the emitter resistor (R_E) and the operating voltage (V_C) depends on the load current and voltage requirements.

a. Resistor Coupling



$$\frac{R_1 \cdot R_2}{R_1 + R_2} = 50\Omega \;\&\; R_3 > 10\,R_2$$

b. Capacitor Coupling



$$\frac{R_1 \cdot R_2 \cdot R_3}{R_1 \cdot R_2 + R_2 \cdot R_3 + R_1 \cdot R_3} = 50\Omega,\; 50\,C_2 > \text{Pulse Width} \;\&\; \frac{3}{50C_2} > \text{Rep Rate}$$

Figure 2-2. Networks for Transistor Load

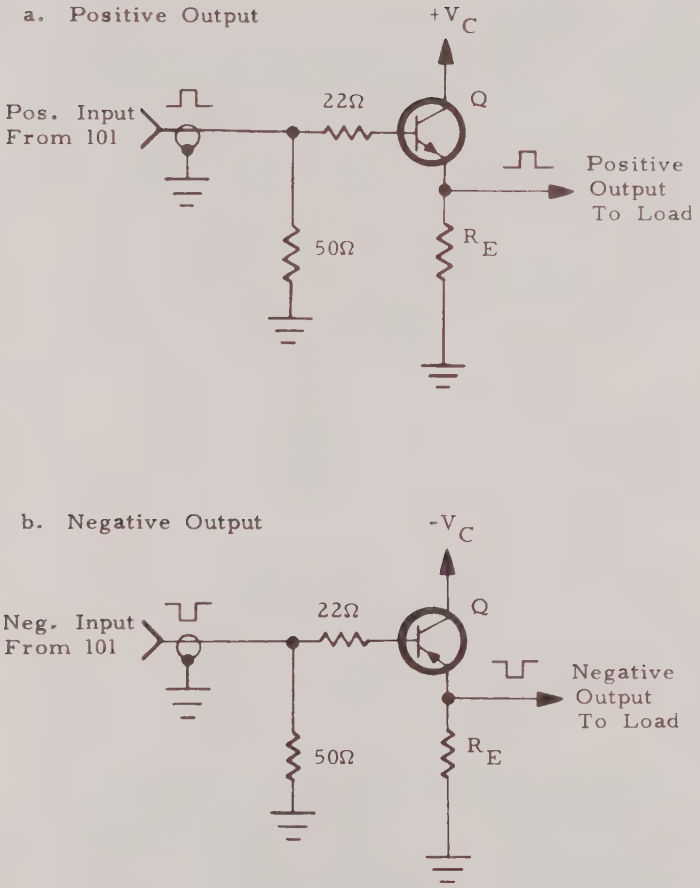
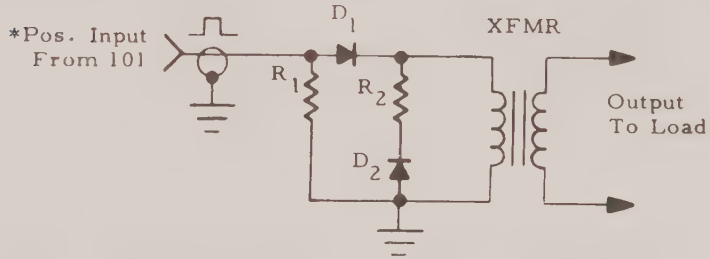


Figure 2-3. Output Decoupling Circuits

2.4.6 Reactive Loads

Reactive loads connected directly to the output will produce pulse distortion; inductive loads may damage the instrument. When it is necessary to drive an inductive load such as a pulse transformer, the instrument should be protected against the inverse voltages generated by energy stored in the transformer. Figure 2-4 shows how diodes may be used to dampen the reverse voltage swings and prevent the output transistors from being exposed to voltages above their inverse ratings.



R_1 = 75 - 150Ω, R_2 - 200 - 500Ω, Diodes may be 1N995s.

* Reverse Diode Polarity for Negative Pulse Input.

Figure 2-4. Reverse Voltage Protection

2.4.7 Duty Cycle

Output instability may occur at high duty cycle operation due to failure of the width or delay circuit. Using the lowest ranges that will give the required settings will sometimes correct the problem. This helps stabilize the width and delay circuits by reducing the recovery times to a minimum and extends duty cycle range to the full capability of the instrument. In addition the probability of output pulse distortion due to too much vernier attenuation of the pulse delay or width ranges is lessened.

2.4.8 Output Mixing

Same polarity outputs may be diode mixed and opposite polarity outputs may be resistor mixed, but outputs may not be directly coupled together nor connected to loads at other than ground potential. Pulse

amplitude reduction is substantial for resistor mixing but is negligible for diode mixing. In general, mixing will degrade transition times and cause pulse distortion due to unavoidable reactive components in the coupling circuit. Best results for combining two same polarity outputs is obtained by using a Datapulse 2302 Pulse Mixer.

When two or more outputs are mixed, the loading circuit must protect all outputs from same polarity voltages above the base-to-emitter breakdown voltage of the output transistors (5 volts). Diodes provide excellent protection because they have low forward resistance and are back biased by same polarity outputs. Resistor networks may be used for voltage division but should be such that each instrument is terminated in 50 ohms. Correct coupling connections for mixing two same or opposite polarity outputs are given in Figure 2-5.

2.4.9 Low Level Outputs

Pulse distortion due to overshoot may be excessive at low outputs. The aberrations can be reduced by using a times ten attenuator for outputs below one volt. A Tektronix Number 011-059 T-pad is suitable but is rated at one-half watt and must be restricted to low duty cycle operation for outputs above one-half volt.

2.4.10 Variable Rise Time

The Datapulse 2401 Rise Time Integrator, available as an accessory, provides continuously variable control of rise time up to more than 40 nanoseconds. The unit connects in series with the output and may be used with either positive or negative pulses. No external power is required.

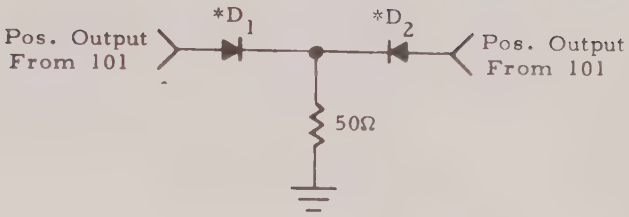
2.4.11 Negative Reference Triggers

The positive trigger outputs may be adapted to applications requiring negative reference triggers by means of the Datapulse 2101 Inverting Transformer, available as an accessory.

2.5 DEFINITIONS

Refer to Figure 2-6 for a graphical representation of the following definitions.

a. Same Polarity Mixing.



* Reverse Diodes for Negative Outputs

b. Opposite Polarity Mixing.

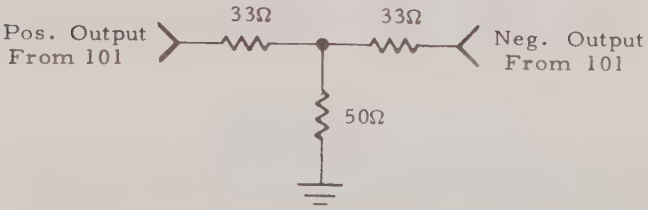


Figure 2-5. Output Mixing

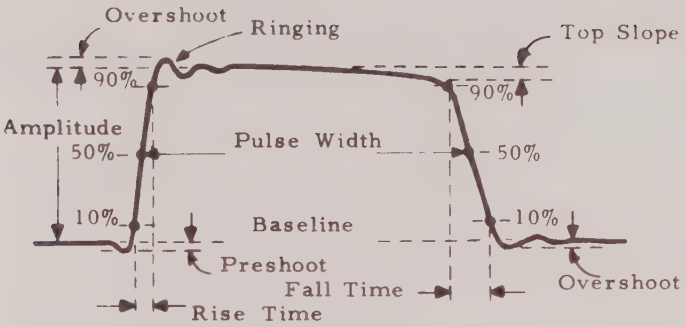


Figure 2-6. Output Pulse Characteristics

2.5.1 Main Output

The principal output of the instrument, available at the POS and NEG OUTPUT jacks.

2.5.2 Pulse Delay

The separation in time of the main pulse from the reference trigger in the single pulse mode, or the separation between the first and second pulse in the double pulse mode, measured between the 50% points of the leading edges.

2.5.3 Pulse Width

The pulse duration measured at the 50% point of the leading and trailing edges.

2.5.4 Rise and Fall Time

The transition time of the pulse leading and trailing edges measured between the 10% and 90% amplitude levels.

2.5.5 Duty Cycle

The ratio of the pulse on time to the total time of the pulse period.

2.5.6 Trigger Outputs

Synchronous trigger pulses occurring at the repetition rate of the main pulse and available at the ADVANCED and REFERENCE TRIGGER OUTPUT jacks.

Reference Trigger: Zero time reference for the main pulse.

Advanced Trigger: Auxiliary reference trigger available on internally triggered operations.

2.5.7 Internal Operation

The mode of operation in which the synchronizing clock pulse for the instrument is supplied internally by the rate oscillator and governed by the REPETITION RATE controls.

2.5.8 External Operation

The mode of operation in which the synchronizing clock pulse is supplied and controlled by an external source connected to the TRIGGER INPUT jack.

2.5.9 Gated Operation

In this mode of operation, the main outputs are turned on for the duration of pulses applied to the ENABLING GATE INPUT jack and off between gate pulses so that the main pulses occur in gated bursts.

2.5.10 Waveform Aberrations

Any small deviation from the standard wave shape pattern including overshoot, preshoot, ringing and top slope expressed in percentage of pulse amplitude.

Ringing: Damped oscillations occurring on the leading corner of the pulse top or at the base of the trailing edge.

Overshoot: Maximum excursion above the pulse top at the leading edge or dip below the baseline at the trailing edge caused by ringing.

Preshoot: Dip below the baseline at the leading edge, or rise above the pulse top at the trailing edge.

Top Slope: Pulse top sag or droop.

2.5.11 Jitter

Small rapid variations in a waveform observed as unsteadiness of the oscilloscope trace and indicating cycle to cycle variations of pulse parameters.

2.5.12 Clock Pulse

The basic synchronous trigger pulse that establishes the time base for all circuits within the instrument and determines the repetition rate of the main pulse.

2.5.13 Pulse Mode

Refer to paragraph 2.2.7 (Pulse Mode) under paragraph 2.2 (Controls and Connectors).

2.5.14 Line Slope

Refer to paragraph 2.2.2 (Repetition Rate) under paragraph 2.2 (Controls and Connectors).

SECTION III

THEORY OF OPERATION

3.1 GENERAL DESCRIPTION

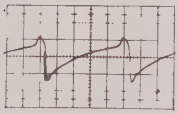
Refer to the Block Diagram (drawing 41000-193) and the Waveform Diagrams (Figure 3-1) for the following discussions.

The clock pulse that synchronizes the operation of all circuits within the instrument is either supplied by an external source or is provided internally by the variable frequency rate oscillator. On internal operation, the output of the rate oscillator (1C) is applied to the trigger multivibrator and to the advance trigger amplifier. The advance trigger amplifier provides an auxiliary reference trigger output on internally triggered operations. The trigger multivibrator generates the trigger pulse (1D) that governs the remaining circuits for all modes of triggering.

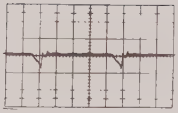
For either external or line slope (line voltage) triggering, the rate oscillator is turned off and the external trigger amplifier turned on so that the external trigger amplifier output (1B) drives the trigger multivibrator. Both the rate oscillator and the external trigger amplifier are off for single pulse operation when a pushbutton is used to trip the trigger multivibrator for one cycle of output. No advance trigger occurs during external, line slope, or manual triggering.

The AND gate permits the delay multivibrator to be either driven continuously by the trigger multivibrator or turned on and off by gate pulses from the external gate amplifier. The main output is continuous in the non-gated mode of operation but is interrupted and occurs in gated bursts in either of the two gated modes of switch S2. The external gate amplifier turns the rate oscillator on and off in the synchronous mode so that the output pulse train is synchronized to the leading edge of the gating waveform and is turned off at the trailing edge. The advance trigger output is also gated in this mode.

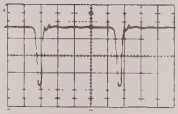
In the asynchronous mode, the output of the external gate amplifier is applied to the gate emitter follower to control the delay multivibrator rather than the rate oscillator. The output of the trigger multivibrator is gated but the advance trigger output is continuous because the rate oscillator is not interrupted. The output pulse train begins with the first advance trigger output after the gate pulse occurs and continuous until the



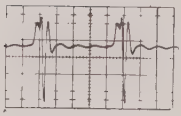
TP (P), 0.5 V/CM
Rate Oscillator



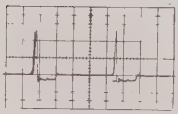
TP (1B), 0.5 V/CM
Trigger MV Input



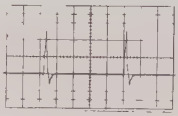
TP (1C), 0.5 V/CM
Oscillator Output



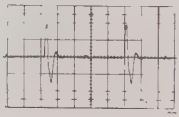
TP (1D), 0.5 V/CM
Trigger MV Output



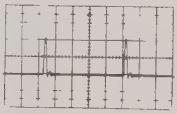
TP (F), 1 V/CM
Delay MV Output



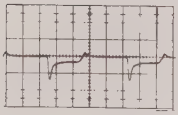
TP (S), 1 V/CM
Delay MV Output



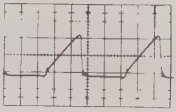
TP (AD), 1 V/CM
Pulse Xmfr. Input



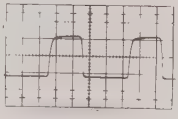
TP (W), 1 V/CM
Reference Trigger



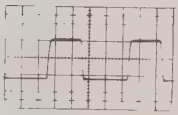
TP (1E), 1 V/CM
Pulse Xmfr. Output



TP (X), 1 V/CM
Width MV Output

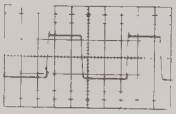


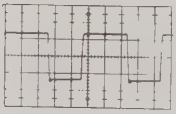
TP (2A), 5 V/CM
Pos. Driver Input



TP (2 B), 5 V/CM
Neg. Driver Input

TP (2 C), 5 V/CM
Pos. Ampl. Input
and Pos. Output





TP (2 D), 5 V/CM
Neg. Ampl. Input
and Neg. Output.

REPETITION RATE: 2 MHz, PULSE DELAY: Minimum, PULSE WIDTH: 0.2 μs, AMPLITUDES: 6 V, GATED MODE: NON-GATED, PULSE MODE: SGL, OSCILLOSCOPE: Real Time, 50 MHz Bandpass, 10 M ohm Probe, 0.1 μs/CM Sweep Speed, and zero time at same point on all diagrams.

Figure 3-1. Waveform Diagrams

gate pulse subsides. The reference trigger output, which is taken from the delay multivibrator is gated in both modes.

The leading and trailing edges of the delay multivibrator waveform are differentiated to produce two trigger pulses separated by the multivibrator duration (period). These are applied through the OR gate to the width multivibrator, and the trigger at the beginning of the delay interval is also applied to the reference trigger amplifier. Switch S71 disconnects the leading trigger pulse from the input to the width multivibrator (1E) in the single pulse mode and the main output is a single pulse separated in time from the reference trigger output by the delay period.

In the double pulse mode, the width multivibrator is turned on twice during each cycle to produce two identical pulses. The first pulse occurs approximately 30 nanoseconds after the reference trigger and the second at the end of the delay multivibrator duration. Pulse width is determined by the width multivibrator duration for either single or double pulse operation.

The output of the width multivibrator (2A) is applied to the output drivers which raise the current level to generate the drive (2C) for the positive output amplifier. An inverted version (2B) generates the drive (2D) for the negative output amplifier. Variable bridged-T attenuators provide output pulse amplitude control. The current sensitive overload protection circuits turn the respective power supplies off when either output is overloaded.

3.2 CIRCUIT DESCRIPTION

3.2.1 Repetition Rate Oscillator

The repetition rate oscillator, shown in simplified form in Figure 3-2 is an emitter coupled multivibrator. Transistors Q2 and Q4 comprise the basic oscillator, and Q3 is an emitter follower that drives timing capacitor C_T. The voltage waveform occurring at the base of Q4 is illustrated in Figure 3-1 (Waveform Diagrams) for a repetition rate of two megahertz.

To trace the cycle of operation, assume that Q2 has just turned off and Q4 is starting to conduct. A positive voltage step occurs at the collector of Q2 (and the base of Q3) because the voltage drop in resistor R8 is suddenly reduced when the collector current in Q2 is turned off. This positive transient is transferred through emitter follower Q3 and timing

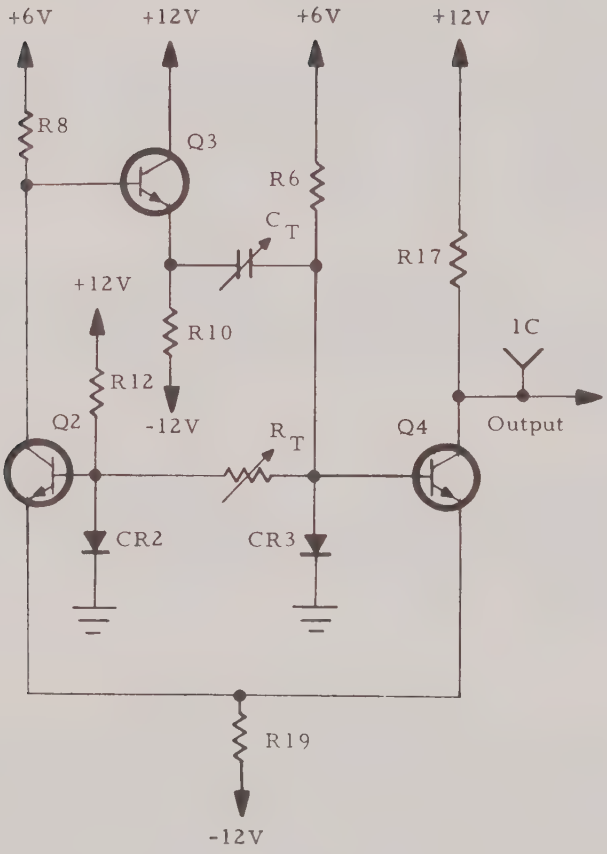


Figure 3-2. Repetition Rate Oscillator

capacitor C_T to the base of Q4 and drives Q4 into a high state of conduction. The voltage drop produced in resistor R19 by emitter current in Q4 holds the emitters of both Q2 and Q4 near ground potential. During the positive transient Q3 conducts freely and provides a low impedance path so that C_T charges through CR3.

The charging current for C_T quickly subsides because the base of Q4 is clamped slightly above ground by CR3, and C_T cannot charge above this voltage level. As the positive voltage at the base of Q4 drops off, an amplified reduction in Q4 emitter current occurs due to the declining base current. The resulting decrease in the voltage drop in R19 drives the emitters of Q2 and Q4 negative. When the emitter of Q2 becomes negative with respect to the base of Q2, which is clamped near ground by CR2, Q2 turns on and conducts through R8.

The negative transient applied to the base of Q3, when Q2 is turned on, drives Q3 to near cutoff and the negative voltage is transferred to the base of Q4 through C_T. This cuts Q4 off sharply and regeneratively drives Q2 into saturation. Diode CR3 presents a high impedance to the negative voltage at the base of Q4 and C_T must charge through timing resistor R_T. This causes the base voltage of Q4 to rise exponentially toward the slightly positive voltage of CR2. Emitter current in Q2 holds the emitter of Q4 near ground, and when the base voltage of Q4 becomes positive with respect to the emitter, Q4 starts to conduct. Emitter current in Q4 cuts Q2 off by driving the emitter of Q2 positive with respect to the base, and the cycle starts over again.

3.2.2 Trigger Multivibrator

Tunnel diode CR50, transistor Q8, and the related circuit components comprise the trigger multivibrator as shown in Figure 3-3. The trigger multivibrator is driven by the rate oscillator for internally triggered modes and generates the trigger pulse that governs the remaining circuits. The external trigger amplifier drives the multivibrator for either external or line voltage triggering, and the circuit is tripped directly by the +12 volt supply for manual single pulse operation.

The negative-going waveform that drives the trigger multivibrator for the internal triggering mode is taken from the collector of Q4 (test point 1C) and occurs when Q4 is regeneratively turned on and then off. When Q4 is off, current flows from the +12 volt supply through resistor R17, diode CR52, and tunnel diode CR50 to the +6 volt supply, CR50 is in the high voltage state, and the voltage at the collector of Q4 is equal to +6 volts

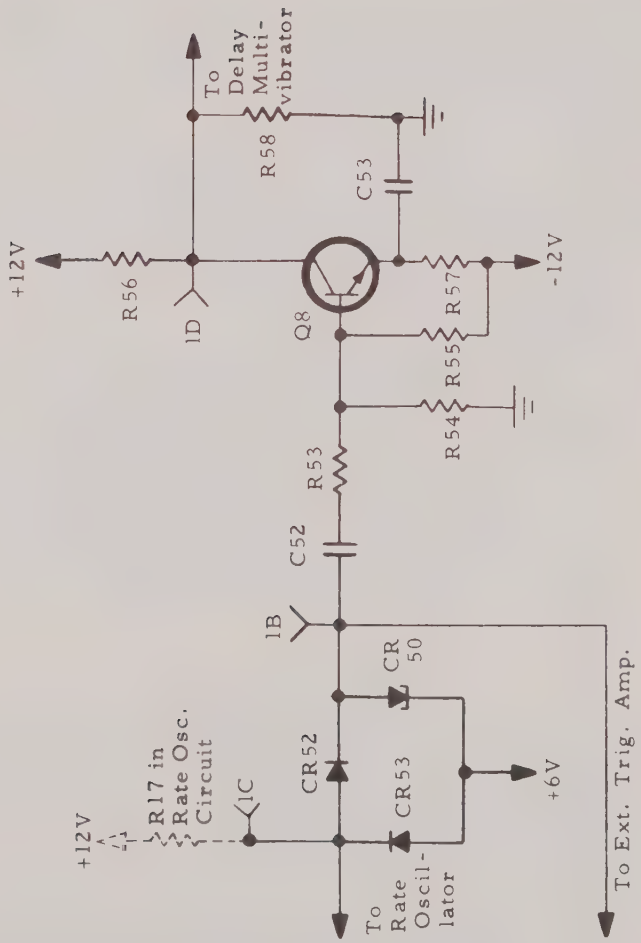


Figure 3-3. Trigger Multivibrator

plus the forward voltage drop in CR50 and CR52. When Q4 is turned on, CR53 clamps the collector of Q4 to +6 volts less the forward drop in CR53, and CR50 is switched to the low voltage state.

Waveform (1B) is a negative-going pulse that occurs when CR50 is switched from the high voltage state to the low state and back again as Q4 turns on and off. This waveform is differentiated by capacitor C52 and resistor R53 so that a negative pulse is applied to the base of Q8 at the leading edge of the waveform followed by a positive trigger at the trailing edge. Pulse amplifier Q8 is biased on by the voltage divider of R54 and R55, and capacitor C53 provides fast response to transient inputs. The output of Q8 (1D) consists of a positive pulse followed by a sharper negative pulse that triggers the delay multivibrator.

3.2.3 External Trigger Amplifier

Current switching drive for the trigger multivibrator is provided by the external trigger amplifier in the external and line voltage triggering modes. The basic circuit is a differential amplifier comprised of transistors Q5 and Q6 and diodes CR30 through CR33 as shown in the simplified schematic of Figure 3-4. Coupling capacitors C31 and C32 remove any dc component in the input signal, and triggering level potentiometer R36 is used to bias Q5 on or off as required by the polarity of the trigger input.

When repetition rate switch S1 is in a positive position (either line or external trigger slope) and Q5 is biased off by the setting of R36, Q6 is on. No current can flow to the trigger multivibrator circuit and tunnel diode CR50 is in the low voltage state because CR31 is back biased by these control settings, the cathode of CR50 is at +6 volts, and when Q6 conducts the collector of Q6 is clamped to +6 volts less the forward drop in CR33. The emitter of Q5 is held slightly below ground by the base-emitter drop in Q6, and Q5 is turned on by a positive trigger input that overcomes the bias at the base of Q5. This turns Q6 off and CR50 is driven to the high voltage state by current from the +12 volt supply through R32 and CR31. When the input signal subsides, Q5 turns off, Q6 turns on, and CR50 returns to the low voltage state until the next trigger turns Q5 on again.

When S1 is switched to a negative position with Q5 biased off by the setting of R36, CR50 is driven to the high voltage state by current from the +12 volt supply through R31 and CR30. For negative external triggering, R36 must be adjusted until Q5 just turns on and drives CR50 to the low voltage state by back biasing CR30. Negative triggers drive CR50

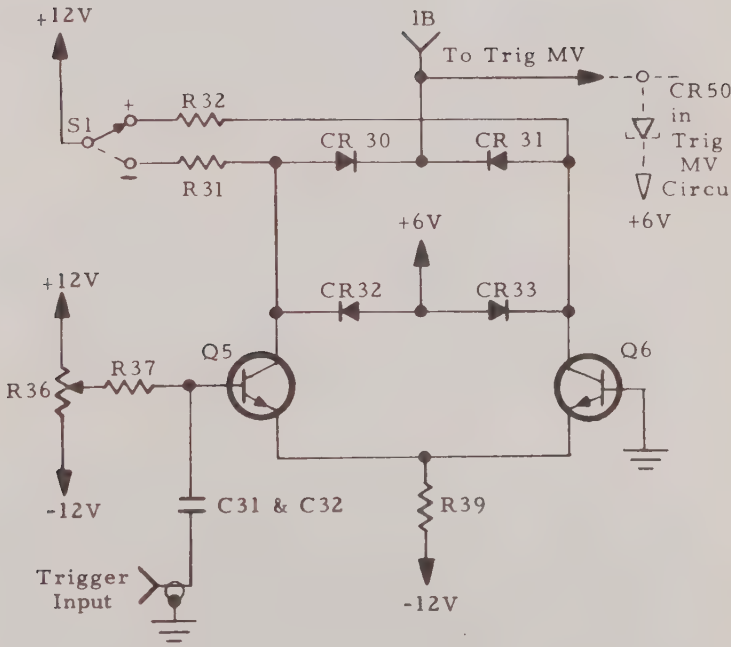


Figure 3-4. External Trigger Amplifier

to the high state in this case by turning Q5 off, rather than on, as in positive triggering.

3.2.4 Gating Circuit

Gate control of the main pulse output is provided by the circuit consisting of external gate amplifier Q1, gate mode switch S2, and gate emitter follower Q9 in the schematic diagram (drawing 40000-484). The normally continuous pulse output is turned off when switch S2 is in either gate position and occurs only during the pulse interval of an applied gate signal. The rate oscillator is gated in the synchronous mode and the delay multivibrator is gated in the asynchronous mode.

External gate amplifier Q1 operates as a switch that is normally off and is turned on by positive pulses applied to the enabling gate input. In synchronous gating, switch S1 connects the output (collector) of Q1 to the base of Q3 through resistor R7 and to the base of Q4 through R4 and diode CR1. Current from the +12 volt supply through R3, R4, CR1 and CR3 keeps Q4 biased on so that the rate oscillator is turned off in the absence of a gate pulse. A positive-going gate pulse, applied to the base, turns Q1 on and the resulting negative transient at the collector of Q1 is applied to the base of emitter follower Q3. This negative transient is transferred through one of the timing capacitors to the base of Q4 and starts the rate oscillator by turning Q4 off. Oscillations continue until the gate pulse subsides and Q4 is biased on again by the forward drop of CR3.

In the asynchronous mode, the collector of gating switch Q1 is connected to the base of gate emitter follower Q9, and the rate oscillator and trigger multivibrator operate continuously. Current from the +12 volt supply through R3, R50 and R51 to the -12 volt supply applies a positive bias to the base of Q9, and turns Q9 on. Emitter current in Q9 produces a voltage drop in R58 and back biases diodes CR49 and CR51. The positive voltage on the diodes is greater than the negative swing at the collector of Q8, and the output of the multivibrator is inhibited until Q9 is turned off by a gate pulse. Thus the AND function is implemented in this gating mode so that the output pulses occur only when trigger pulses and gate pulses are concurrent.

3.2.5 Delay Multivibrator

Pulse delay is determined by the period of the one-shot multivibrator comprised of Q10 and Q11 and the related circuit components in the simplified schematic of Figure 3-5. Both transistors are nor-

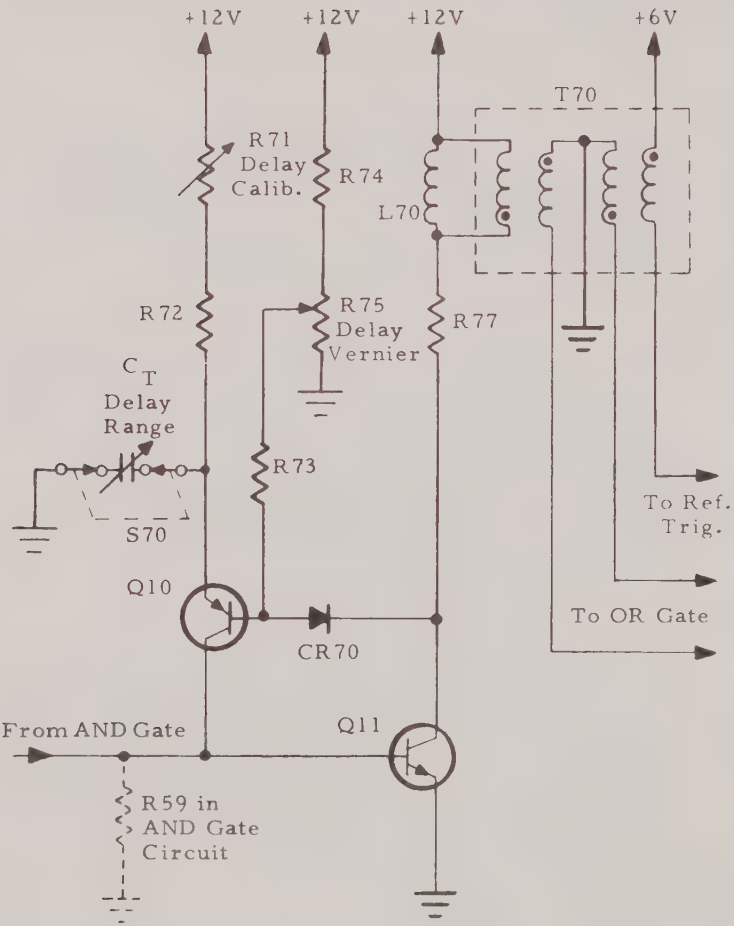


Figure 3-5. Delay Multivibrator

mally on and are regeneratively turned off by negative triggers from the AND gate. At the end of the delay period, determined by the time constant of the circuit, Q10 and Q11 are automatically restored to the stable ON state. The time constant is controlled by the delay range switch and vernier which select the value of C_T and the voltage level of the charge of C_T, respectively.

To visualize the operation of the delay one-shot assume that a negative trigger, applied to the base of Q11 by the AND gate has just turned Q11 off. Diode CR70 is back biased by the resulting positive swing at the collector of Q11, the base of Q10 rises sharply from near ground to the positive setting of delay vernier R75, and Q10 is also suddenly cut off. Timing capacitor C_T charges towards +12 volts through resistor R72 and delay calibration control R71, and when the voltage at the collector of Q10 becomes positive with respect to the voltage setting of R75, Q10 turns on again. Emitter current in Q10 through R59 turns Q11 on, emitter current in Q11 through R77 forward biases CR70, the base-emitter junction voltage of Q10 goes negative, and the circuit is regeneratively restored to the quiescent ON state.

Sharp output trigger pulses for the width multivibrator and the reference trigger output are obtained from pulse transformer T70. Two negative trigger pulses are supplied to the width multivibrator through the OR gate by separate windings of opposite polarity; one pulse occurs when Q11 turns off at the beginning of the delay interval and the other at the end when Q11 turns on again. Inductor L70 sharpens the transient applied to T70 by the voltage swing at the collector of Q11.

3.2.6 Trigger Outputs

Two trigger outputs are provided. The reference trigger is taken from the delay multivibrator and is synchronized to either the internal rate oscillator or an external trigger source. The auxiliary advance trigger is taken from the rate oscillator and does not occur during external, line slope, or manual triggering when the rate oscillator is off. Both triggers are gated in the synchronous mode while only the reference trigger is gated in the asynchronous mode, and the advance trigger output is continuous.

Advance trigger amplifier Q7 in the schematic diagram is driven by the rectangular pulse at the collector of Q4 when the rate oscillator is on. The negative-going leading edge of the pulse is inverted by Q7 and differentiated by emitter bypass capacitor C55 to produce sharp positive pulses at the collector of Q7. Resistor R62 provides 50 ohms source termination for the trigger output.

Negative trigger pulses that occur at the beginning of the delay interval are applied to the base of reference trigger amplifier Q12 by pulse transformer T70. Amplified positive versions of these pulses appear at the collector of Q12 and are applied to the output by 50 ohm source resistor R81. Diode CR71 clamps the emitter of Q12 to +6 volts and prevents Q12 from responding to positive inputs. The triggers are counted down when the delay interval is greater than the clock pulse period.

3.2.7 Width Multivibrator

Transistors Q13 and Q14 and the related circuit components in the schematic diagram comprise the width multivibrator circuit which is identical to the delay one-shot multivibrator. Transistors Q13 and Q14, like Q10 and Q11 in the delay circuit, are quiescently on. Pulse width is determined by the time required for the transistors to return to the stable ON state after being turned off by a negative trigger from the OR gate. Timing capacitors C90 through C95 are selected by width range switch S90, variable resistor R91 is the range calibration adjustment, and potentiometer R95 provides vernier control of each range.

Negative trigger pulses occurring at the beginning and at the end of the pulse delay interval are applied to diodes CR72 and CR73 in the OR gate circuit. Pulse mode switch S71 disconnects the first pulse from CR73 in the single position so that the width one-shot multivibrator is triggered only at the end of the delay interval. In the double pulse mode, the width circuit is triggered twice during each clock period to produce two identical pulses separated by the delay interval. The positive output pulses at the collector of Q14 are dc coupled to the base of Q15 in the output driver circuit.

3.2.8 Output Drivers and Amplifiers

Transistors Q15 through Q18 in the simplified schematic of Figure 3-6 are the output drivers, and Q19 through Q22 are the output amplifiers. The negative output amplifier circuit is a mirror image of the positive amplifier with PNP, rather than NPN transistors and is not shown. The drivers are overdriven amplifiers and the output amplifiers are emitter followers.

Between pulses the base of Q15, which is dc coupled to the collector of Q14 in the width circuit is slightly positive with respect to ground because the emitter of Q14 is grounded and Q14 is quiescently on. However the voltage across R10 due to collector current in Q15 is insuf-

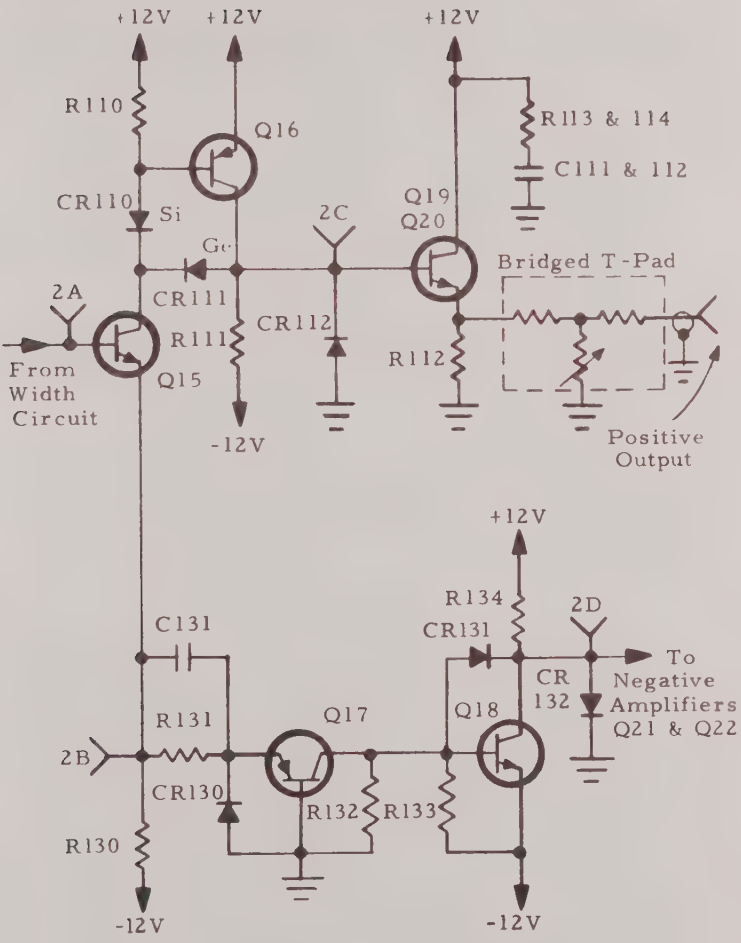


Figure 3-6. Output Drivers and Amplifiers

ficient to forward bias Q16, and Q16 is near cutoff. Diode CR112 is forward biased by current through R111 to the -12 volt supply, CR111 is back biased, and the slightly negative voltage at the base of Q19 and Q20 biases the two positive output amplifiers off.

The near vertical leading edge of the positive pulse applied to the base of Q15 produces a sudden negative swing at the collector of Q15 and drives Q16 to the threshold of saturation. The collector of Q16 rises sharply towards +12 volts but is restrained by the Baker clamp of CR110 and CR111; the base-collector voltage of Q16 locks to the difference between the cut-in voltage of silicon diode CR110 and the lower cut-in voltage of germanium diode CR111. At the edge of saturation, the gain of Q16 is greatly reduced, pulse top aberrations are attenuated, and stored charge effects normally experienced in saturation are avoided. CR112 is back biased by the positive voltage at the collector of Q16, and Q16 remains on until abruptly turned off by the trailing edge of the applied pulse. Baseline undershoot and aberrations are sliced off between pulses when the collector of Q16 is driven to the slightly negative voltage of CR112.

The output at the emitters of Q19 and Q20 is a replica of the sharply defined rectangular pulse at the collector of Q16 with the power level increased to meet the output requirements. The filter network of R113, R114, C111 and C112 decouples the output from the power supply to eliminate switching noise effects. The bridged-T attenuator provides a continuously variable output with a source impedance of approximately 50 ohms over most of the amplitude range.

Input for the negative output driver is taken from tne emitter of Q15 which is near ground between pulses. Current through CR130, R131 and R130 to the -12 volt supply back biases Q17 by the forward drop in CR130. The voltage divider of R132 and R133 holds the collector of Q17 and the base of Q18 near -12 volts. The voltage drop in R133 is insufficient to forward bias the base of Q18, and Q18 is near cut off. The collector of Q18 is slightly above ground, CR131 is back biased, and output amplifiers Q21 and Q22 (not shown) are biased off by the forward drop of CR132.

Emitter current in Q15 through R130 applies an abrupt positive voltage swing to the emitter of Q17 when Q15 is turned on hard by the pulse from the width circuit. Buffer Q17 conducts heavily through R133 and turns Q18 on by driving the base of Q18 positive. The collector of Q18 goes sharply negative but is restrained at the threshold of saturation by the base-collector clamp voltage of CR131. Diode CR132 is back

biased, and Q21 and Q22 are turned on during the pulse interval. The output amplifiers are turned off by the trailing edge of the applied pulse, and baseline aberrations are sliced off by the slightly positive voltage of CR132. The negative output is an inverted replica of the positive output and has a separate attenuator for continuously variable amplitude control.

The circuit comprised of R112, C113 and CR113 through CR115 (not shown in the simplified schematic) eliminates negative overshoot in the positive output. Capacitor C113 charges to approximately 1.4 volts (forward voltage of CR113 and CR114) during the pulse interval. Between pulses CR115 is forward biased, and C113 supplies positive current to cancel out negative overshoot. A mirror image circuit eliminates positive overshoot from the negative output.

3.2.9 Power Supply and Overload Protection

Positive and negative dc voltages for the instrument are provided by two mirror image series regulator circuits supplied by a single bridge rectifier as shown in the Power Supply schematic (drawing 40000-480). Power transformer T501 has two primary windings that are connected either in series by selector switch S501 for operation from 230 volt inputs, or parallel for 115 volt inputs. Regulated +6 volts is obtained from the +12 volt supply by zener diode CR507 and emitter follower Q504.

Zener diode CR506 is connected between the output of the +12 volt supply and the base of error amplifier Q503 to provide the reference voltage for the supply. Any change in the output voltage produces an error signal that is amplified by Q503 and applied to the base of series regulator Q501. The response of Q501 to this input is a change in the collector-emitter voltage that is equal and opposite to the output voltage error. The high gain and fast response of this feedback control circuit restricts the output voltage to minor fluctuations in spite of substantial changes in line voltage and load current.

Overload currents in the +12 volt supply increase the voltage drop in series resistor R515 until the base of current limiter Q502 is forward biased. This turns Q502 on and prevents excessive currents because the base of Q501 is back biased when Q502 conducts.

The regulator circuit for the -12 volt supply is identical to the +12 volt regulator except that the polarity of the transistors is PNP rather than NPN. Capacitors C501 through C513 are filters.

SECTION IV

MAINTENANCE

4.1 PREVENTIVE MAINTENANCE

Proper care and correct use with regularly scheduled inspections provide the best protection against unnecessary repairs and down time. The Datapulse Model 101 is a sensitive laboratory instrument and should not be exposed to severe environmental conditions either in use or in storage. Contaminating or damaging exposure must be avoided at all times if long life and uninterrupted service are expected.

4.1.1 Inspection

Inspection intervals should be based on frequency of use and the severity of the environment to which the instrument is exposed. Remove the top and bottom dust covers by loosening the four quarter-turn fasteners on each cover. The perforated side panels held on by self-tapping screws should normally be left on. Inspect for dirt and corrosion and for loose, broken, or burnt parts and wiring. Circuit board discoloration caused by heat may usually be disregarded unless the instrument is inoperative.

4.1.2 Cleaning

Accumulated dust and dirt should be removed as often as required. Use either low velocity dry air or a soft nonmetallic brush to clear the interior of foreign matter. Clean dirty parts with a solvent such as trichlorethylene or MEK (methyl ethyl ketone) using a soft cloth, and a cotton tipped applicator for narrow spaces. After cleaning, a small amount of lubriplate should be applied to the ball bearing in the detent plates of the front panel rotary switches.

4.1.3 Recalibration

The instrument is correctly calibrated when it leaves the factory. However, calibration should be checked at regularly scheduled intervals of either accumulated operating hours or calendar time; 500 operating hours or six-month intervals are recommended. Refer to paragraph 4.4 for complete calibration instructions.

4.2 PARTS REMOVAL

A procedure should be carefully thought out before a part is removed to avoid unnecessary disassembly and accidental damage. Refer to the parts list (Section V) and use only direct replacements for parts affecting performance. Transistors temporarily removed should be returned to the original sockets unless defective. Replacement of some parts will necessitate recalibration.

4.2.1 Power Transistors

The power transistors for the dc power supply are mounted on the back panel under a cover plate. Fiber bushings and mica washers are used to electrically insulate the case (collector) of the transistors from the panel (chassis ground) and a thin film of silicon grease (such as Dow Corning DC–4) is applied to both sides of the mica washers to insure proper thermal conductivity. Incorrectly installed, the transistors may either short out or overheat and fail.

4.2.2 Selected Components

In some cases the value of a component is selected in production to avoid the use of a calibration adjustment. These components are marked with a asterisk on the schematic diagram, and it should not be necessary to alter the values throughout the life of the instrument. If replacement of a damaged part does not restore proper operation of the instrument, the factory or nearest Datapulse representative should be contacted for assistance.

4.2.3 Soldering

Only experienced technicians should replace soldered parts because printed circuits are vulnerable to excess heat as are many diodes and transistors. The following recommendations should be taken into consideration when replacing soldered parts;

a. Use small diameter rosin core solder and a 35 to 40 watt iron with a wedge or pointed tip, 1/16 to 1/8 inch wide. The tip must be clean and properly tinned with excess solder removed.

b. Obviously defective parts may be clipped out so the leads can be conveniently unsoldered from the board.

c. Solder only on the circuit side of the board, not on the component side.

d. Apply the tip of the iron directly to the solder joint, at the eyelet, just long enough for the solder to flow.

e. Avoid bringing the iron into contact with the circuit board; overheating will cause the conductor to lift from the board.

f. Use a solder sipper (or some other means) to remove excess solder first when unsoldering a lead, particularly where a lead is bent over so the lead can be straightened and pulled out.

g. When a lead is free, clean the hole and remove excess solder, using a solder sipper or a sharp object such as a toothpick or pointed tool.

h. To prevent heat damage when soldering heat sensitive components, use a heat sink or long nose pliers to grip the lead between the part and the board.

i. Leave a small space between the circuit board and the part when soldering heat dissipating components such as resistors.

j. Clean the area thoroughly after soldering.

4.3 TROUBLESHOOTING

Before concluding that an instrument is in need of repair, be sure the instrument is being operated correctly and is not out of calibration. Check for faulty operation by following the steps of paragraph 2.3, and use the procedure in paragraph 4.4 to verify calibration. A replaced or aging component may cause an apparent malfunction that is readily corrected by a calibration adjustment. Test equipment and connectors are frequent sources of trouble and should be double checked. Refer to Table 4-1 for troubleshooting suggestions.

When neither the instrument nor the pilot lamp will go on the trouble is probably in the input power circuit. An instrument that is

operating incorrectly and is clearly in need of maintenance should be thoroughly inspected for obvious or apparent damage before the circuits are checked. The power supply, which is usually all right when the quiescent output and ripple voltages are correct should be checked before the pulse forming circuits are suspected. To locate components on the circuit board, refer to Figure 4-1 (Parts Location).

4.3.1 Input Power Circuit

A general purpose VOM (volt-ohm-milliammeter) is needed for the following checks:

a. Make sure the line cord is correctly connected and making contact with the power source connector.

b. Remove the fuse from the back panel and check for continuity. Replace the fuse.

c. Check the position of the 115/230 volt selector switch on the back panel.

d. Measure the line voltage at the source and check for agreement with the setting of the 115/230 voltage selector switch.

e. Remove the top cover and check for line voltage between points BA and BR in the right rear corner of the circuit board.

NOTE: Refer to the Power Supply schematic for the circuit location of test points, and refer to Figure 4-1 for the physical location.

f. Check for line voltage between points BC and BR (this includes the fuse circuit).

g. Verify line voltage between points BE and BR with the POWER switch ON.

h. Measure the transformer secondary voltage between points BG and BH on the left side of the transformer. The voltage should be approximately 38 volts ac at nominal line voltage.

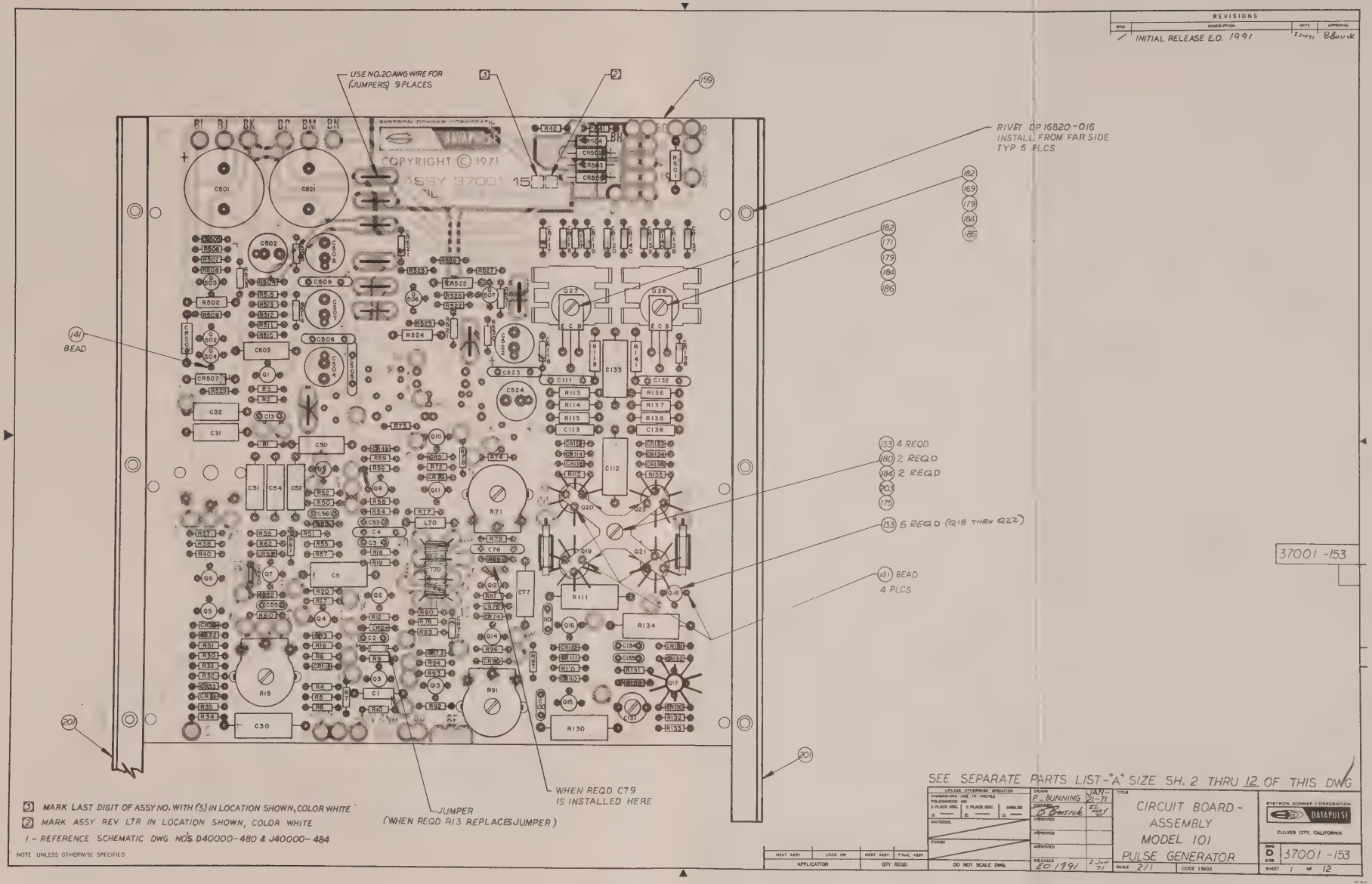

REVISIONS
INITIAL RELEASE E.O. 1991
USE NO.20 AWG WIRE FOR (JUMPERS) 9 PLACES
RIVET DP16820-016 INSTALL FROM FAR SIDE TYP 6 PLCS
(141) BEAD
(33) 4 REQD
(180) 2 REQD
(184) 2 REQD
(133) 5 REQD (Q18 THRU Q22)
(31) BEAD 4 PLCS
37001-153
JUMPER (WHEN REQD R13 REPLACES JUMPER)
WHEN REQD C79 IS INSTALLED HERE
[3] MARK LAST DIGIT OF ASSY NO. WITH (3) IN LOCATION SHOWN, COLOR WHITE
[2] MARK ASSY REV LTR IN LOCATION SHOWN, COLOR WHITE
1 - REFERENCE SCHEMATIC DWG NOS. D40000-480 & J40000-484
NOTE UNLESS OTHERWISE SPECIFIED
SEE SEPARATE PARTS LIST-"A" SIZE SH. 2 THRU 12 OF THIS DWG
CIRCUIT BOARD - ASSEMBLY MODEL 101 PULSE GENERATOR
DATAPULSE
CULVER CITY, CALIFORNIA
37001-153

Figure 4-1. Parts Location - Schematic 37001-153

	TROUBLE		CHECK
1.	Instrument and pilot lamp won't go on when the POWER switch is turned ON.	1.	Check the input power circuit. a. Verify line voltage (115) at the source. b. Check the 115/230 slide switch position. c. Check the fuse for continuity. d. Verify line voltage between BR and BC, and BR and BE.
2.	Pilot lamp lights dimly.	2.	Check the 115/230 slide switch position.
3.	Pilot lamp lights but instrument does not operate.	3.	Check the power supply circuit. a. Check the +12 to +14, +5 to +6.5, and -12 to -14 volt dc outputs. b. Verify 40 to 44 volts dc between BJ and BM (at 117 volts ac input). c. Verify 36 to 40 volts ac between BG and BH (at 117 volts ac input).
4.	Fuse blows when instrument is turned on.	4.	Check for shorted rectifiers (CR501 through CR504) or shorted filter capacitors (C501 and C502).
5.	Unregulated dc voltage too low (BJ to BM).	5.	Check for open rectifier (CR501 through CR504).
6.	+12 to +14 and +5 to +6.5 volt dc outputs too high.	6.	Check positive regulator circuit. a. Check for shorted zener (CR505). b. Check for burnt 4.7 ohm resistor (R512 through R514). c. Check regulation (vary line voltage + and - 10%).
7.	-12 to -14 volt dc output too high.	7.	Check negative regulator circuit. a. Check for shorted zener (CR506). b. Check regulation (vary line voltage).
8.	+12 to +14 volt dc output too low.	8.	Check series regulator Q501.
9.	-12 to -14 volt dc output too low.	9.	Check series regulator Q505.
10.	Positive dc output does not regulate.	10.	Check error amplifier Q503.
11.	Negative dc output does not regulate.	11.	Check error amplifier Q506.
12.	+5 to +6.5 dc output too low but +12 to +14 dc output all right.	12.	Check emitter follower Q504 and zener CR507.
13.	Q23 fails when positive output is shorted.	13.	Check current limiter Q502.
14.	Q24 fails when negative output is shorted.	14.	Check current limiter Q507.
15.	4.7 ohm resistor (R512 through R514) burnt.	15.	Check for shorted positive dc output. a. Check for short in triggering level control R36.
16.	Positive output baseline above ground.	16.	Check for shorted output transistor (Q19 and Q20). Also check power supply positive dc output.
17.	Negative output baseline below ground.	17.	Check for shorted output transistor (Q21 and Q22). Also check power supply negative dc output.
18.	Positive output pulse aberration too high.	18.	Check for open output transistor (Q19 and Q20).
19.	Negative output pulse aberration too high.	19.	Check for open output transistor (Q21 and Q22).
20.	No positive output but negative output all right.	*20.	Check waveform at 2C. a. If all right, check circuit between 2C and output jack. b. If not all right, check circuit between 2B and 2C.
21.	No negative output but positive output all right.	*21.	Check waveform at 2D. a. If all right, check circuit between 2D and output jack. b. If not all right, check circuit between 2B and 2D.
22.	Both main outputs absent but both trigger outputs all right.	*22.	Check waveforms at 2B, 2A and 1E. a. When 2A but not 2B is all right, check circuit of Q15. b. Check width circuit (Q13, Q14 and S90) when 1E but not 2A is all right.
23.	Both main outputs and reference trigger absent but advance trigger all right.	*23.	Check the waveforms at 1B and 1D. a. Check tunnel diode CR50 if 1B is not correct. b. Check the circuit of Q8 if 1B is all right but not 1D. c. Check the delay circuit (Q10, Q11 and S70) if 1D is all right.
24.	Both main outputs and both trigger outputs absent.	*24.	Check the waveform at 1C. a. If 1C is all right, check Q7 and make the checks of step 23. b. If 1C is not correct, check the waveform at P (base of Q4). c. Check the rate oscillator (Q2, Q3, Q4, S1 and S2) if the waveform at P is not correct.

*Check waveforms by comparing the actual test point waveform to the corresponding waveform of Figure 3-1, using the control settings given for Figure 3-1.

Table 4-1. Troubleshooting

4.3.2 Power Supply

The REPETITION RATE selector must be in the SINGLE PULSE position and the POWER switch must be ON for the following checks:

a. Measure the dc voltages (+12, +6 and -12). The voltage points are labeled on the [redacted] of the circuit board near the back, and the values are referenced to chassis ground.

Bottom

b. Use an oscilloscope (or any other suitable means) to measure the quiescent ripple voltage. The ripple is typically 2 millivolts peak-to-peak for all three dc outputs.

NOTE: The ripple voltage is much higher when the power supply is under load.

c. Measure the unregulated output of the bridge rectifier between points BJ and BM. The output should be approximately 42 volts dc at nominal line voltage.

d. Check the dc voltages under load by setting the 101 controls as follows: REPETITION RATE controls: 1.0 MHz; PULSE WIDTH controls: 0.5 μs; AMPLITUDE controls: minimum; GATE MODE switch: NON-GATED; PULSE MODE switch: SGL; and the remaining controls in any position. Verify that the dc voltages do not change noticeably from the values measured in step (b).

NOTE: Many power supply failures are caused by collector-emitter shorts in transistors and anode-cathode shorts in rectifiers and zener diodes. A shorted semiconductor will exhibit low resistance in both directions.

4.3.3 Pulse Circuits

After verifying that the power supply is operating correctly, the remaining circuits should be inspected again for visual damage that may have been overlooked. However, do not assume that a problem is solved when an obviously defective part is replaced because the part failure may

be the result of a more basic cause. An operational check (paragraph 2.3) will sometimes give an indication of the location of the trouble. Calibration adjustments (paragraph 4.4) should be double checked before a circuit is condemned. The theory of operation (Section III) and the schematic diagram should be studied thoroughly before an attempt is made to troubleshoot any of the circuits. Refer to Figures 4-1 through 4-3 for the location of circuit components and test points.

Excessive pulse aberration in the output indicates that one output transistor (Q19 and Q20 or Q21 and Q22) is open. If an output transistor is shorted, the pulse baseline will shift above ground for the positive output and below for the negative. However, the power supply should also be checked if the baseline is off ground because a dc voltage that is too high produces the same effect. One output transistor may be shorted while the other is open but this becomes apparent when the transistors are replaced one at a time.

When there is no pulse at the main output, the best way to locate the trouble is to compare the actual test point waveforms to the waveforms of Figure 3-1 (be sure the control settings are the same as those given for Figure 3-1). Check the other main output first when one output is faulty, and if the second output is satisfactory, the trouble is probably in the output driver and amplifier circuit (between test point 2B and the absent output). Monitor 2C when the positive output is missing, or 2D when there is positive but no negative output, to determine whether the trouble is in the driver (Q15 and Q16 or Q17 and Q18) or the amplifier (Q19 and Q20 or Q21 and Q22) circuit.

Check the trigger outputs when both main outputs are absent and if both are present, monitor test points 2A, 2B and 1E in turn. Suspect Q15 when the waveform is correct at 2A but not at 2B. Look for trouble in the width circuit (Q13, Q14 and S90) when the waveform is all right at 1E but not at 2A. A bad waveform at 1E indicates that the problem is in the circuit between pulse transformer T70 and test point 1E.

Tunnel diode CR50 is the most likely offender if all outputs except the advance trigger are absent, and CR50 can be checked at 1B. Troubleshoot the delay circuit (Q10, Q11 and S70) if the trigger multivibrator waveforms (1B and 1D) and the advance trigger are all right. When all outputs are absent, check the waveforms at the base of Q4 (test point P) and if waveform P is unsatisfactory, look for trouble in the rate oscillator circuit (Q2 through Q4 and S1); also check the gate mode switch (S2) circuit.

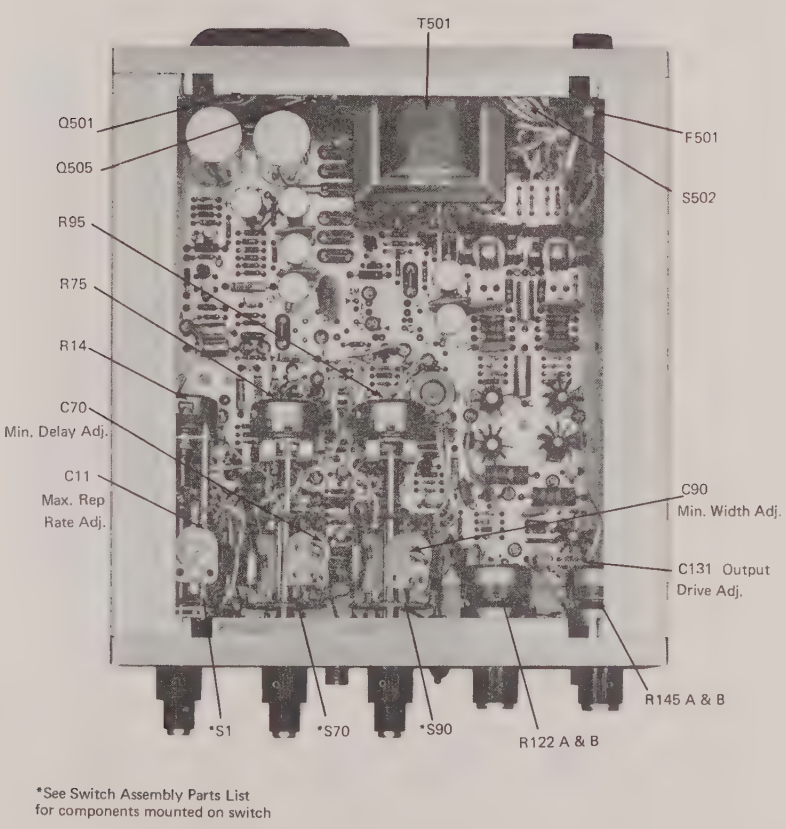


Figure 4-2. Top View-Model 101

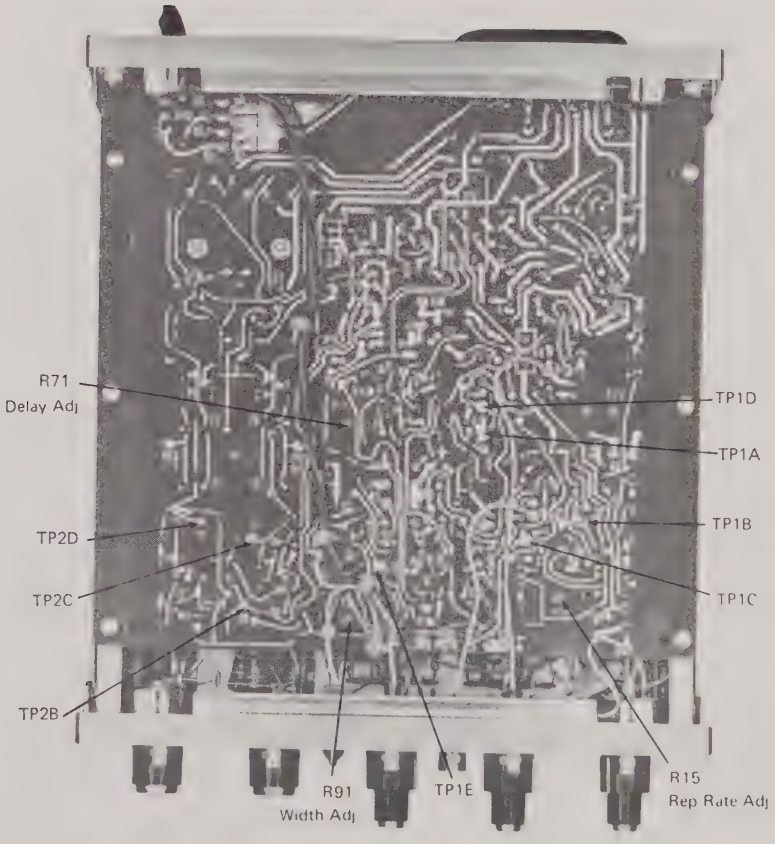


Figure 4-3. Bottom View-Model 101

The absence of a trigger output, when the main outputs are satisfactory, should be attributed to the circuit of Q7 if the advance trigger is missing, or to the circuit of Q12 if there is no reference trigger. When an instrument operates correctly but cannot be triggered from an external source, troubleshoot the external trigger amplifier circuit (Q5, Q6 and S1). Check the circuit containing Q1, Q9 and S2 for gating circuit problems.

4.4 CALIBRATION

Calibration adjustments should only be made when necessary and only when instruments with the required accuracies are available. Adjustments are limited to the accuracy of the calibrating instrument which is typically ±3% for most oscilloscopes and general purpose voltmeters. When an instrument appears to be out of calibration, power supply voltages should be checked before any adjustments are made. Normally the sequence of this procedure need not be followed, and individual adjustments may be made when necessary. However interaction between the variable resistors and trimmer capacitors in the repetition rate, delay, and width circuits makes it necessary to adjust the resistors first.

All seven calibration controls are accessible when the top and bottom covers are removed. An insulated tip screwdriver should be used to adjust the four trimmer capacitors. Refer to Figures 4-1 through 4-3 for the location of calibration controls and test points.

4.4.1 Equipment (or equivalent) Required

a. A multiple range dc voltmeter with an accuracy of ±3% such as a general purpose VOM (volt-ohm-milliammeter).

b. A general purpose oscilloscope of at least 15 megahertz bandpass with triggered sweep and a dual trace amplifier.

c. A sampling oscilloscope with a rise time of 0.4 nanoseconds and a dual trace amplifier.

d. A 50 ohm coaxial termination with BNC connectors capable of 2 watts dissipation such as a Datapulse 2003A Power Termination.

NOTE: A standard one watt termination is adequate for most combinations of control settings but should be used with care because pulse output power approaches 2 watts for high duty cycle waveforms at full amplitude.

e. A 50 ohm coaxial termination with BNC connectors capable of ½ watt dissipation.

f. A 50 ohm, 20:1 (or two 10:1) coaxial attenuator with GR connectors capable of 2 watts dissipation (see note after step (d) if a lower wattage attenuator is used).

g. A 50 ohm, 10:1 coaxial attenuator with BNC connectors capable of ½ watt dissipation.

h. Three 50 ohm coaxial cables (3-4 feet long) with BNC connectors.

i. Two BNC Tee connectors.

j. Two GR to BNC female coaxial adaptors.

k. A small insulated tip (low capacitance) screwdriver.

4.4.2 Power Supply Check

CAUTION

Check the position of the 115/230 volt slide switch on the back panel for agreement with the line voltage before connecting the power cord.

a. Remove the top and bottom covers by turning the four quick-release fasteners on each cover one-quarter turn.

b. Connect the instrument to a suitable power source, and turn the POWER switch ON.

c. Turn the REPETITION RATE selector to the SINGLE PULSE position, and check the dc voltages for the indicated tolerances (the voltage points are labeled on [redacted] of the main circuit board, near the back).
Bottom

1. +12 to +14 volts dc.
2. -12 to -14 volts dc.
3. +5 to +6.5 volts dc.

} 2 mV P.P. ripple

4.4.3 Repetition Rate Calibration

Variable resistor R15 (on schematic 40000-484) is in the left front corner of the main circuit board, and trimmer capacitor C11 is on top of the repetition rate switch assembly.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE range	1.0 MHz
REPETITION RATE vernier	fully clockwise
PULSE DELAY controls	minimum
PULSE WIDTH range	0.1 μs
PULSE WIDTH vernier	fully clockwise
GATE MODE switch	NON-GATED
PULSE MODE switch	SGL
Remaining controls	any position

b. Monitor the POS OUTPUT on the general purpose oscilloscope with the output terminated in 50 ohms (2 watts) at the oscilloscope, and synchronize the oscilloscope externally from the ADVANCED TRIGGER OUTPUT also terminated in 50 ohms (½ watt) at the oscilloscope.

c. Set the oscilloscope controls for a convenient display, check the upper limit of all ranges except the 10 MHz range for front panel frequency, and select the range that is lowest with respect to the corresponding front panel indication. If necessary adjust R15 to obtain the front panel frequency for the selected range.

NOTE: The above method is necessary for full range coverage because R15 affects all ranges.

d. Turn the PULSE WIDTH controls to minimum and the REPETITION RATE controls to maximum. If necessary adjust C11 for a repetition rate of 10 megahertz.

e. Check all ranges for front panel frequency at the upper end and for overlap at the lower end (a convenient pulse width setting is one-tenth the rate oscillator period). If full range coverage is not provided, return the instrument to the settings of step (a) and repeat steps (c) through (e).

NOTE: If full range coverage is not possible, one or more of the timing capacitors on the repetition rate switch assembly C6 through C12 may be out of tolerance.

4.4.4 Pulse Width Calibration

Variable resistor R91 is on the front edge of the main circuit board near the width switch, and trimmer capacitor C90 is on the width switch assembly.

a. Retain the test connections of step (a) of the previous paragraph (4.4.3) and set the instrument controls as follows:

Control	Setting
REPETITION RATE range	0.1 MHz
REPETITION RATE vernier	fully clockwise
PULSE DELAY controls	minimum
PULSE WIDTH range	1.0 μs
PULSE WIDTH vernier	fully clockwise
GATE MODE switch	NON-GATED
PULSE MODE switch	SGL
Remaining controls	any position

b. Set the oscilloscope controls for a convenient display, check the upper limit of all ranges except the 0.1 μs range for front panel pulse width, and select the range that is lowest with respect to the corresponding front

panel indication. If necessary adjust R91 to obtain the front panel pulse width for the selected range.

NOTE: If the upper limit of a range is not obtained, the corresponding capacitor on the width switch assembly (C91 through C95) may be out of tolerance. The 1000:1 coverage of pulse width and delay makes it unnecessary to check for overlap at the low end of each range.

c. Monitor the POS OUTPUT on the sampling oscilloscope and synchronize the oscilloscope externally from either TRIGGER OUTPUT using the 20:1 attenuator for the main output and the 10:1 attenuator for the trigger output.

NOTE: When an attenuator is not required, the trigger output should be terminated in 50 ohms.

d. Turn the PULSE WIDTH selector to 0.1 μs and the REPETITION RATE selector to 1.0 MHz with both verniers fully clockwise. Check the upper limit of the range for a pulse width of 0.1 microsecond, and then turn the vernier fully counterclockwise and check the lower limit for a width of 35 nanoseconds. If necessary adjust C90 for full range coverage.

NOTE: For optimum results, repeat steps (b) through (d).

4.4.5 Pulse Delay Calibration

Variable resistor R71 is near the center of the main circuit board labeled DEL on top of the board, and trimmer capacitor C70 is on the delay switch assembly.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE range	0.1 MHz
REPETITION RATE vernier	fully clockwise
PULSE DELAY range	1.0 μs

Control	Setting
PULSE DELAY vernier	fully clockwise
PULSE WIDTH range	1.0 μs
PULSE WIDTH vernier	fully clockwise
GATE MODE switch	NON-GATED
PULSE MODE switch	SGL
Remaining controls	any position

b. Simultaneously monitor the POS OUTPUT and the REFERENCE TRIGGER OUTPUT on the general purpose oscilloscope by means of the dual trace amplifier with both outputs terminated in 50 ohms at the oscilloscope, and synchronize the oscilloscope externally to the REFERENCE TRIGGER OUTPUT.

c. Set the oscilloscope controls for a convenient display, check the upper limit of all ranges except the 0.1 μs range for front panel pulse delay, and select the range that is lowest with respect to the corresponding front panel indication. If necessary adjust R71 to obtain the front panel pulse delay for the selected range.

NOTE: If the specified upper limit of a range is not obtained, the corresponding capacitor on the delay switch assembly (C71 through C75) may be out of tolerance.

d. Simultaneously monitor the POS OUTPUT and the REFERENCE TRIGGER OUTPUT on the sampling oscilloscope by means of the dual trace amplifier with both outputs attenuated (or terminated in 50 ohms if attenuation is not required), and synchronize the oscilloscope externally to the REFERENCE TRIGGER OUTPUT.

e. Turn the PULSE DELAY selector to 0.1 μs and the REPETITION RATE selector to 1.0 MHz with both vernier fully clockwise, and turn the PULSE WIDTH controls to minimum. Check the upper limit of the range for a pulse delay of 0.1 microseconds, and then turn the vernier fully counterclockwise and check the lower limit for a delay of 40 nanoseconds. If necessary adjust C70 for full range coverage.

NOTE: For optimum results, repeat steps (b) through (e).

4.4.6 Output Driver Calibration

Trimmer capacitor C131 is on the front edge of the main circuit board between the two front panel amplitude controls.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	5-10 MHz
PULSE WIDTH controls	minimum
GATE MODE switch	NON-GATED
PULSE MODE switch	SGL
Remaining controls	any position

b. Monitor the NEG OUTPUT on the sampling oscilloscope using the 20:1 attenuator, and synchronize the oscilloscope from either TRIGGER OUTPUT with the trigger either attenuated or terminated, as required.

c. Set the oscilloscope controls and the NEGATIVE AMPLITUDE for a convenient display, and adjust C131 for minimum pulse width and steepest rise time without exceeding the specified pulse aberration.

SECTION V

PARTS LIST

5.1 ABBREVIATIONS AND SYMBOLS

5.1.1 Reference Designations

Reference designations used are the assigned circuit symbols in the following schematic diagrams:

Drawing Number 40000-484
Drawing Number 40000-480

Resistors are designated as R1, R2, R3, etc., and are in ohms, fixed value, composition, 5% and ¼ watt unless otherwise specified.

Capacitors are designated as C1, C2, C3, etc., and are in picofarads, fixed value, dipped mica, 5% (except electrolytics) and 500 volts dc unless otherwise specified.

Transistors are designated as Q1, Q2, Q3, etc., and are silicon unless otherwise specified.

Diodes are designated as CR1, CR2, CR3; inductors as L1, L2, L3; switches as S1, S2, S3, etc.

5.1.2 Abbreviations

ampere	A
alternating current	ac
coefficient	Coef.
concentric	Conc.
direct current	dc
kilohm	k
manufacturer	MFR.
microfarad	μF
milliampere	mA
milliwatt	mW
miniature	Min.
negative-positive-negative	NPN
number	NO.
microhenry	μH

electrolytic	Elect.
double-pole-double-throw	DPDT
position	Pos.
positive-negative-positive	PNP
quantity	QTY.
reference	REF.
section	Sec.
single-pole-double-throw	SPDT
temperature	Temp.
variable	Var.
volts	V
watts	W
wire wound	WW
silvered mica	SM
tantalum	Ta.
ceramic	Cer.
germanium	Ge.
transformer	Xfmr.
Joint Electronic Device Engineering Council	JEDEC
silicon	Si.

5.1.3 *Manufacturers

Allen Bradley Company	AB
Bussman Manufacturing Company	Buss
Centralab	CRL
Chicago Telephone Supply	CTS
C & K Components	C&K
Continental-Wirt	C–W
Corning Glass Works	Corning
Datapulse Division	DP
Drake Manufacturing Company	Drake
Elco Corporation	Elco
Electro Motive Manufacturing Company	Elmenco
Erie Technological Products Incorporated	Erie
Fairchild Semiconductor Products Incorporated	FT

*Manufacturers are not listed when JEDEC part numbers are given.

IMB Electronic Products	IMB
Littelfuse Incorporated	Littelfuse
Magnetic Components Incorporated	MCI
Motorola Semiconductor Products Incorporated	Motorola
Oak Manufacturing Company	Oak
Radio Corporation of America	RCA
Radio Materials Company	RMC
Sangamo Electric Company	Sangamo
Semcor Division of Components Incorporated	Semcor
Sprague Electric Company	Sprague
Switchcraft Incorporated	Switch
TRW Capacitor Division of TRW Incorporated	TRW
Wakefield Engineering Incorporated	WE
Wilco Corporation	Wilco
Richey Electronics Incorporated	Richey

NOTE: Manufacturers and manufacturer's part numbers are listed to facilitate field maintenance but are subject to change without notice. When differences exist between the listed part and the part in the instrument, the listed part may be considered a suitable replacement if it has the same electrical and/or mechanical characteristics. If a design change has been made, the characteristics of the new part will be listed in the Addenda and Errata section, at the end of the manual.

5.2 REPETITION RATE SWITCH ASSEMBLY

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
R11	1	51	10010-510	AB	CB5105
R14	1	Var., 10 k, 2 W, 10%, Mod. Log.	20043-103	AB	JA1N056S103BA
R21	1	100	10010-101	AB	CB1015
C6	1	8.2 μF, 20 V, 10%, Ta.	11511-825	Sprague	150D825X9020B2
C7	1	1 μF 200 V, 1%, Mylar	11124-105	IMB	ZA2C105F
C8	1	0.1 μF, 200 V, 1%, Mylar	11124-104	IMB	ZA2C104F
C9	1	0.01 μF, 300 V, 1%, SM	11025-103	Sangamo	CRK3C103F
C10	1	820, 1%, SM	11027-821	Elmenco	CM20D821F
C11	1	Var., 7–45, Cer., Temp. Coef. N500	11307-450	Erie	503-000-33C
C12	1	33, SM	11017-330	Sangamo	DR5E330J
S1	1	Rotary, 11 Pos., 2 Sec., Conc., 30^{O} Throw, Shorting	25250-037	Oak	256741-J2

5.3 PULSE DELAY SWITCH ASSEMBLY

R70	1	47	10010-470	AB	CB4705
R75	1	Var., 10 k, 2 W, 10%, Linear	20053-103	AB	JA1N056S103UA
C70	1	Var., 7–45, Cer., Temp. Coef. N500	11307-450	Erie	503-000-33C
C71	1	430, 1%, SM	11027-431	Sangamo	RR5E431F
C72	1	4700, 300 V, 1%, SM	11025-472	Sangamo	CR3C472F
C73	1	0.047 μF, 100 V, Mylar	11089-473	IMB	MA2B473J

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
C74	1	0.47 μF, 200 V, 1%, Mylar	11124-474	IMB	ZA2C474F
C75	1	5 μF, 15 V, Elect.	11151-505	Sprague	30D505G015BAZM8
S70	1	Rotary, 6 Pos., 2 Sec., Conc., 45° Throw, Shorting	25250-033	Oak	245021-AF2

5.4 PULSE WIDTH SWITCH ASSEMBLY

R90	1	47	10010-470	AB	CB4705
R95	1	Var., 10 k, 2 W, 10%, Linear	20053-103	AB	JA1N056S103UA
C90	1	Var., 7–45, Cer., Temp. Coef. N500	11307-450	Erie	503-000-33C
C91	1	430, 1%, SM	11027-531	Sangamo	RR5E431F
C92	1	4700, 300 V, 1%, SM	11025-472	Sangamo	CR3C472F
C93	1	0.047 μF, 100 V, Mylar	11089-473	IMB	MA2B473J
C94	1	0.47 μF, 200 V, 1%, Mylar	11124-474	IMB	ZA2C474F
C95	1	5 μF, 15 V, Elect.	11151-505	Sprague	30D505G015BAXM8
S90	1	Rotary, 6 Pos., 2 Sec., Conc., 45° Throw, Shorting	25250-033	Oak	245021-AF2

5.5 FRONT PANEL ASSEMBLY

R36	1	Var., 10 k, 0.1 W, 20%	10980-103	CRL	BA001-8/12
R82	1	680	10010-681	AB	CB6815
R120	4	51, 2 W	10723-510	Corning	RL42S510J
R121		Same as R120			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
R122A, B	2	Var., 50, Dual Ganged, 2 W, 20%	20213-500	AB	JJ88952A
R143		Same as R120			
R144		Same as R120			
R145A, B		Same as R122A, B			
C33*	1	0.1 μF, 75 V, Cer., +80%, -20%	11242-104	RMC	Type TA
C137	2	15	11077-150	Elmenco	DM15E150J
C138		Same as C137			
S2	1	Slide, Min., 0.5 A, 125 V ac, DPDT	15310-001	C–W	G-128-S
S30	1	Pushbutton, 30 W, 250 mA ac, SPDT, Red	15300-001	Sw.	903-1C-Red
S71	1	Slide, Min., 0.5 A, 125 V ac, SPDT	15310-002	C–W	G-124
S501	1	Toggle, SPDT, 5 A, 115 V ac	15280-001	C&K	7101
DS501	1	Indicator, Neon, NE2H, Red	15450-002	Drake	H116-323

5.6 BACK PANEL ASSEMBLY

Q501	1	NPN, MJE3055	12666-001	Motorola	MJE3055
Q505	1	PNP, MJE2955	12616-001	Motorola	MJE2955
S502	1	Slide, 6 A ac, DPDT	15310-003	C–W	G326 Modified
F501	1	Fuse, ½ A, Fast-Blow, 250 V	15470-011	Littelfuse	312-500
T501	1	Power Xfmr.	24010-013	MCI	24010-013

*Value is factory selected and may differ from the value given.

5.7 MAIN CIRCUIT BOARD ASSEMBLY

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
R1	3	3.9 k	10010-392	AB	CB3925
R2	10	1 k	10010-102	AB	CB1025
R3		Same as R2			
R4		Same as R2			
R5	4	4.7 k	10010-472	AB	CB4725
R6	1	100 k	10010-104	AB	CB1045
R7	2	15 k	10010-153	AB	CB1535
R8	2	220	10010-221	AB	CB2215
R9	3	51	10010-510	AB	CB5105
R10		Same as R2			
R12	2	2.7 k	10010-272	AB	CB2725
R13*	2	22	10010-220	AB	CB2205
R15	3	Var., 1 k, 0.2 W, 30%	20240-102	CTS	Series UPM-70
R16	6	200	10010-201	AB	CB2015
R17		Same as R2			
R18		Same as R16			
R19	1	1.2 k	10010-122	AB	CB1225
R20	2	47	10010-470	AB	CB4705
R30	4	10 k	10010-103	AB	CB1035
R31		Same as R2			
R32		Same as R2			
R33		Same as R30			
R34	7	100	10010-101	AB	CB1015
R35		Same as R2			

*Value is factory selected and may differ from the value given.

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
R37		Same as R30			
R38	1	270	10010-271	AB	CB2715
R39	7	1.5 k	10010-152	AB	CB1525
R40		Same as R34			
R41		Same as R7			
R42	2	2.2 k	10010-222	AB	CB2225
R50		Same as R39			
R51		Same as R30			
R52		Same as R34			
R53*	1	68	10010-680	AB	CB6805
R54		Same as R2			
R55	1	1.8 k	10010-182	AB	CB1825
R56		Same as R1			
R57		Same as R39			
R58		Same as R8			
R59		Same as R5			
R60		Same as R2			
R61		Same as R1			
R62*		Same as R9			
R69*	1	27	10010-270	AB	CB2705
R71		Same as R15			
R72		Same as R39			
R73	2	3.3 k	10010-332	AB	CB3325
R74		Same as R5			
R76	2	470	10010-471	AB	CB4715
R77	3	390	10010-391	AB	CB3915

*Value is factory selected and may differ from the value given.

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
R78	1	150	10010-151	AB	CB1515
R79		Same as R76			
R80	5	680	10010-681	AB	CB6815
R81		Same as R9			
R83		Same as R80			
R91		Same as R15			
R92		Same as R39			
R93		Same as R73			
R94		Same as R5			
R96		Same as R80			
R97		Same as R34			
R110		Same as R13			
R111	2	560, ½ W	10011-561	AB	EB5615
R112		Same as R39			
R113	4	1, ½ W	10011-109	AB	EB10G5
R114		Same as R113			
R115	2	4.7, ½ W	10011-479	AB	EB47G5
R117		Same as R2			
R118		Same as R113			
R130	1	560	10010-561	AB	CB5615
R131*	1	430	10010-431	AB	CB4315
R132	1	5.6 k	10010-562	AB	CB5625
R133		Same as R20			
R134		Same as R111			
R135		Same as R39			
R136		Same as R113			

*Value is factory selected and may differ from the value given.

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
R137		Same as R113			
R138		Same as R115			
R139		Same as R12			
R501	1	27 k, ½ W	10011-273	AB	EB2735
R502		Same as R55			
R503	1	33 k, ¼ W, 5%	10010-331	AB	CB3315
R504		Same as R130			
R505		Same as R30			
R506		Same as R16			
R507		Same as R16			
R508		Same as R77			
R509		Same as R34			
R510		Same as R80			
R511		Same as R34			
R512	4	4.7	10010-497	AB	CB47G5
R513		Same as R512			
R514		Same as R512			
R515	1	2.7	10010-279	AB	CB27G5
R516		Same as R512			
R517	1	3.3	10010-339	AB	CB33G5
R520		Same as R80			
R521		Same as R16			
R522		Same as R77			
R523		Same as R16			
R524		Same as R42			
R525		Same as R503			
R526		Same as R130			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
R527		Same as R30			
R528		Same as R34			
R529		Same as R80			
R530		Same as R512			
R531		Same as R515			
C1	1	0.01 μF, 100 V, 10%, Mylar	11083-103	TRW	663UW10391
C2	1	10	11077-100	Sangamo	D155C100J03
C3*	1	6.8, 1000 V, Cer.	11249-689	Sprague	10TCC-V68
C4	8	0.1 μF, 100 V	11242-104	RMC	Type TA
C5	1	10 μF, 15 V, Elect.	11151-106	Sprague	30D106G015BA2M8
C13	1	82	11077-820	Elmenco	DM15E820J
C30	1	1 μF, 50 V, Elect., -20%, +80%	11152-105	Richey	11-215-1-50T
C31	2	5 μF, 15 V, Elect.	11151-505	Sprague	30D505G015BA2M8
C32		Same as C31			
C50	6	0.001μF, 100 V, 10%, Mylar	11083-102	TRW	663UW10291
C51		Same as C50			
C52		Same as C50			
C53	1	470	11077-471	Sangamo	D155F471J03
C54		Same as C50			
C55	1	820	11077-821	Sangamo	D153F821J03
C56	1	47	11077-470	Elmenco	DM15E470J
C76		Same as C4			
C77		Same as C50			
C110	3	0.05 μF, 25 V, +80%, -20%, Cer.	11241-503	RMC	M-25
C111	2	10 μF, 35 V, Ta.	11512-106	Sprague	150D106X9035R2
C113	2	82, SM	11017-820	Sangamo	DR5E820J03

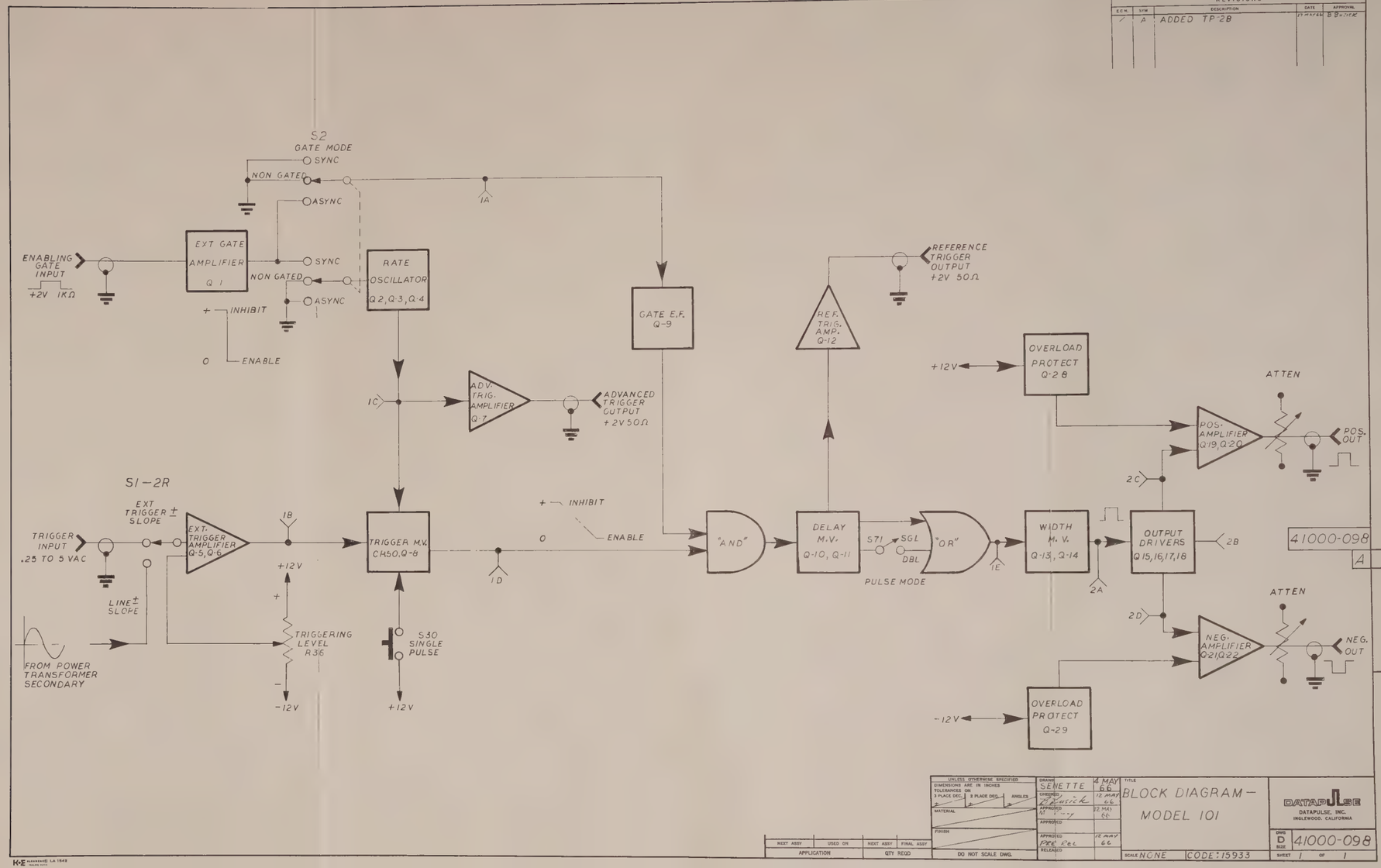
*Value is factory selected and may differ from the value given.

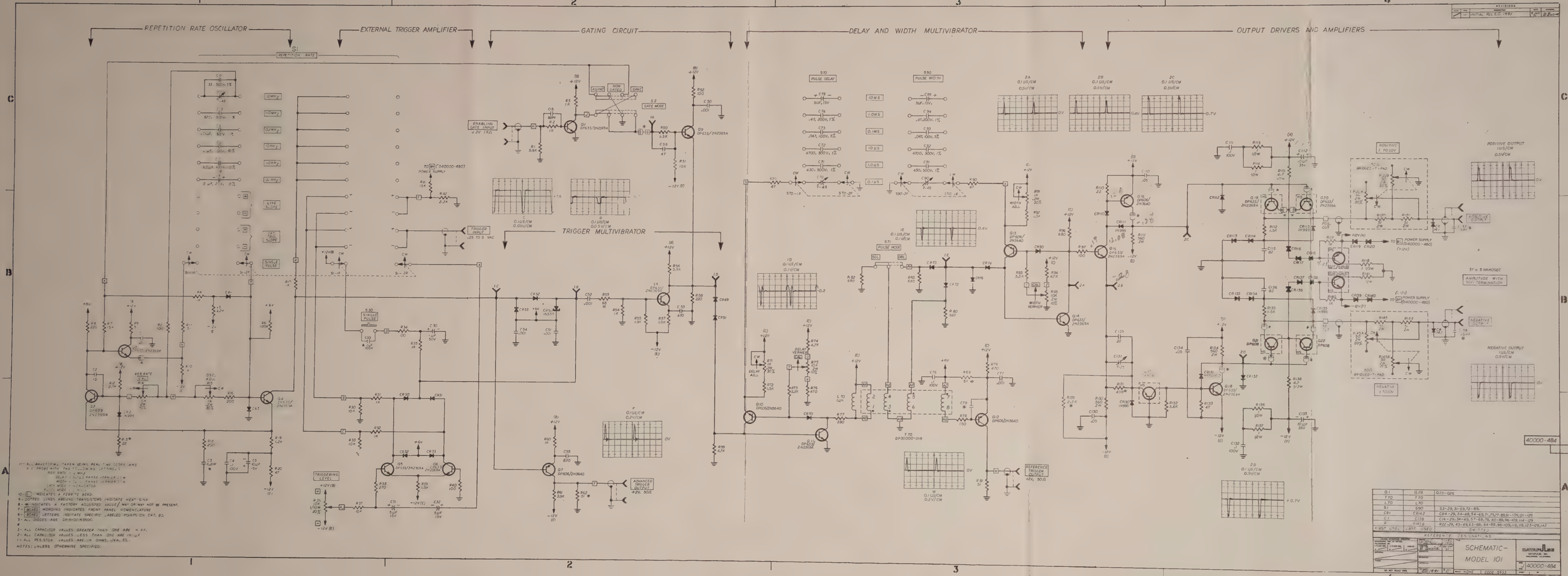
REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
C130		Same as C110			
C131	1	Var., 7–25, 350 V, Cer., Temp. Coef. N300	11305-250	Erie	538014-93B
C132		Same as C4			
C133		Same as C112			
C134		Same as C110			
C135	1	22	11077-220	Sangamo	D155E220J03
C136		Same as C113			
C501	2	1000 μF, 50 V, Elect.	11162-108	Richey	36-1.000-1000-50C
C502	6	100 μF, 35 V, Elect.	11162-107	Richey	20-500-100-35C
C503		Same as C50			
C504		Same as C502			
C505		Same as C4			
C506		Same as C4			
C507		Same as C502			
C508		Same as C502			
C509		Same as C4			
C521		Same as C501			
C522		Same as C502			
C523		Same as C4			
C524		Same as C502			
Q1	17	DP63-3, NPN	22635-003		2N2369A
Q2		Same as Q1			
Q3		Same as Q1			
Q4		Same as Q1			
Q5		Same as Q1			
Q6		Same as Q1			

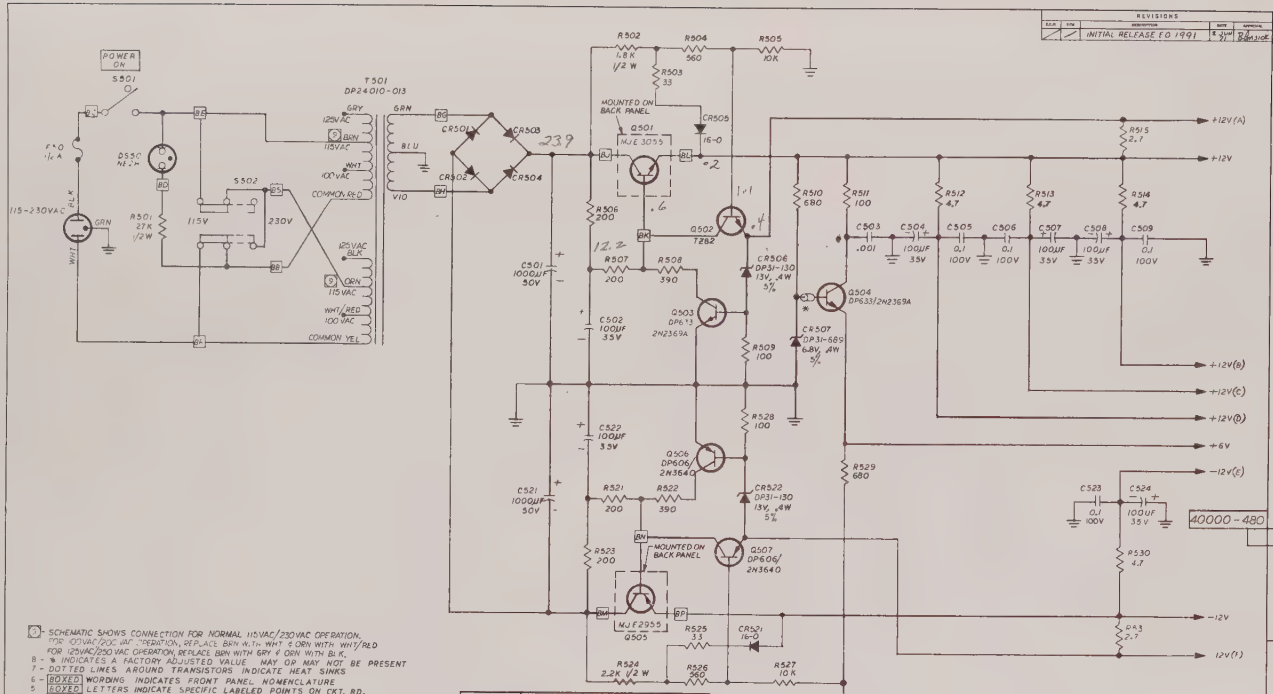
REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
Q7	7	DP60-6, PNP	22605-006		2N3640
Q8		Same as Q1			
Q9		Same as Q1			
Q10		Same as Q7			
Q11		Same as Q1			
Q12		Same as Q7			
Q13		Same as Q7			
Q14		Same as Q1			
Q15		Same as Q1			
Q16		Same as Q7			
Q17	1	DP60-5, PNP	22605-005	FT	FT1702
Q19		Same as Q1			
Q20		Same as Q1			
Q21	2	DP60-1, PNP	22605-001	Motorola	SM4172
Q22		Same as Q21			
Q27	1	2N4918	12616-000	Motorola	2N4918
Q28	1	2N4921	12666-000	Motorola	2N4921
Q502	1	TZ82	12695-007	Sprague	TZ82
Q503		Same as Q1			
Q504		Same as Q1			
Q505	1	PNP, MJE2955	12616-001	Motorola	MJE2955
Q506		Same as Q7			
Q507		Same as Q7			
CR1	23	DP16-0, Si.	22164-000		1N3600
CR2	6	Ge.	12144-003		1N995
CR3		Same as CR1			
CR30		Same as CR1			
CR31		Same as CR1			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
CR32		Same as CR1			
CR33		Same as CR1			
CR49		Same as CR1			
CR50	1	Tunnel, Ge.	12254-001		1N3717
CR51		Same as CR1			
CR52		Same as CR1			
CR53		Same as CR1			
CR70		Same as CR1			
CR72		Same as CR1			
CR73		Same as CR1			
CR74		Same as CR1			
CR76		Same as CR1			
CR90		Same as CR1			
CR110		Same as CR1			
CR111		Same as CR2			
CR112		Same as CR1			
CR113		Same as CR1			
CR114		Same as CR1			
CR115		Same as CR2			
CR116		Same as CR1			
CR117		Same as CR1			
CR118		Same as CR1			
CR119		Same as CR1			
CR120		Same as CR1			
CR130		Same as CR2			
CR131		Same as CR2			
CR132		Same as CR1			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFR. PART NO.
CR133		Same as CR1			
CR134		Same as CR1			
CR135		Same as CR2			
CR136		Same as CR1			
CR137		Same as CR1			
CR138		Same as CR1			
CR139		Same as CR1			
CR140		Same as CR1			
CR501	4	DP19-1, Si.	22194-001		1N4002
CR502		Same as CR501			
CR503		Same as CR501			
CR504		Same as CR501			
CR505		Same as CR1			
CR506	2	Zener, 13 V, 400 mW, 5%	12154-043		1N964B
CR507	1	Zener, 6.8 V, 400 mW, 5%	22314-689		DP31-689
CR521		Same as CR1			
CR522		Same as CR506			
L70	1	Inductor, 1 μH, Phenolic core	14284-002	Wilco	205-11-10
T70	1	Pulse Xfmr.	30000-019	DP	30000-019
	11	Ferrite Bead	19170-000	DP	19170-000


REVISIONS
ECN SYM DESCRIPTION DATE APPROVAL
A ADDED TP-2B
S2
GATE MODE
SYNC
NON GATED
ASYNC
1A
ENABLING GATE INPUT
+2V 1KΩ
EXT GATE AMPLIFIER Q 1
SYNC
NON GATED
ASYNC
RATE OSCILLATOR Q2,Q3,Q4
+ INHIBIT
0 ENABLE
GATE E.F. Q-9
REFERENCE TRIGGER OUTPUT +2V 50Ω
REF. TRIG. AMP. Q-12
1C
ADV. TRIG. AMPLIFIER Q-7
ADVANCED TRIGGER OUTPUT +2V 50Ω
+12V
OVERLOAD PROTECT Q-28
ATTEN
POS. AMPLIFIER Q-19,Q-20
POS. OUT
2C
S1-2R
EXT TRIGGER ± SLOPE
TRIGGER INPUT .25 TO 5 VAC
EXT. TRIGGER AMPLIFIER Q-5,Q-6
1B
TRIGGER M.V. CH50,Q-8
+ INHIBIT
0 ENABLE
"AND"
DELAY M.V. Q-10, Q-11
S7I
SGL
DBL
"OR"
PULSE MODE
1E
WIDTH M. V. Q-13, Q-14
2A
OUTPUT DRIVERS Q 15,16,17,18
2B
41000-098
A
LINE ± SLOPE
FROM POWER TRANSFORMER SECONDARY
+12V
TRIGGERING LEVEL R36
-12V
S30 SINGLE PULSE
+12V
1D
ATTEN
2D
NEG. AMPLIFIER Q21,Q22
NEG. OUT
-12V
OVERLOAD PROTECT Q-29
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON 3 PLACE DEC. ± 2 PLACE DEC. ± ANGLES
MATERIAL
FINISH
DO NOT SCALE DWG.
NEXT ASSY USED ON NEXT ASSY FINAL ASSY
APPLICATION QTY REQD
DRAWN SENETTE 4 MAY 66
CHECKED 12 MAY 66
APPROVED 12 MAY 66
APPROVED
APPROVED 12 MAY 66
RELEASED
TITLE BLOCK DIAGRAM — MODEL 101
DATAPULSE DATAPULSE, INC. INGLEWOOD, CALIFORNIA
SCALE NONE CODE 15933
DWG D SIZE 41000-098
SHEET 1 OF 1


REPETITION RATE OSCILLATOR
EXTERNAL TRIGGER AMPLIFIER
GATING CIRCUIT
DELAY AND WIDTH MULTIVIBRATOR
OUTPUT DRIVERS AND AMPLIFIERS
TRIGGER MULTIVIBRATOR
REPETITION RATE
SINGLE PULSE
ENABLING GATE INPUT
TRIGGER INPUT
PULSE DELAY
PULSE WIDTH
POSITIVE OUTPUT
NEGATIVE OUTPUT
REFERENCE TRIGGER OUTPUT
ADVANCED TRIGGER OUTPUT
NOTES: UNLESS OTHERWISE SPECIFIED:
REVISIONS
INITIAL REL E.O. 1497
SCHEMATIC - MODEL 101
TEKTRONIX, INC.
40000-484



◇ - SCHEMATIC SHOWS CONNECTION FOR NORMAL 115VAC/230VAC OPERATION. FOR 100VAC/200 VAC OPERATION, REPLACE BRN WITH WHT & ORN WITH WHT/RED FOR 125VAC/250 VAC OPERATION, REPLACE BRN WITH GRY & ORN WITH BLK.

8 - * INDICATES A FACTORY ADJUSTED VALUE. MAY OR MAY NOT BE PRESENT

7 - DOTTED LINES AROUND TRANSISTORS INDICATE HEAT SINKS

6 - BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE

5 - BOXED LETTERS INDICATE SPECIFIC LABELED POINTS ON CKT. BD.

4 - ALL RESISTOR VALUES ARE IN OHMS, ¼W, 5%

3 - ALL DIODES ARE DP18-1/IN4002

2 - ALL CAPACITOR VALUES MORE THAN ONE ARE IN PF

1 - ALL CAPACITOR VALUES LESS THAN ONE ARE IN µF

NOTES: UNLESS OTHERWISE SPECIFIED

REFERENCE DESIGNATIONS		
T 501	T501	
DS 501	DS501	
F501	F501	
S501	S502	
Q501	Q507	
CR501	CR522	CR508 THRU CR520
C501	C524	C510 THRU C520
R501	R531	R516 THRU R520, R528
FIRST USED	LAST USED	OMITTED

APPLICATION	QTY REQD
	101
	100A

DO NOT SCALE DRWG.

DRAWN: R.L. BENNING 1991
CHECKED: R.E. Bosick
APPROVED:
RELEASED: EO 1991 8 JUL 91

SCHEMATIC — POWER SUPPLY

DATAPULSE INC. MALIBU, CALIFORNIA

SIZE D | 40000-480

SCALE NONE | CODE 15933 | SHEET 1 OF 1

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
3537	7-27-71	37000-153	Change R503 and R525 from 33 k, P/N10010-331 to 33 ohm, P/N10010-330.
	10-22-71	Manual	Change Section 5.7 Main Circuit Board Assembly as follows: R69 to – Same as R2. R111 to – 560 ohm, 2 W, 5%, P/N10013-561, AB Mfr. P/N HB5615 R130 to – Same as R111. Add R140 – Same as R2 Add R141 – Same as R113 R502 to – 1.8 k, ½ W, 5%, P/N10011-182, AB, Mfr. P/N EN 1825 R503 to – 33 ohm, P/N10010-330, AB, Mfr. P/N CB3305. R525 to – Same as R503. R504 to – 560 ohm, ¼ W, 5%, P/N10010-561, AB, Mfr. P/N CB5615. R506 to – Same as R504

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
			Section 5.7 Main Circuit Board (cont.) R524 to – 2.2 k, ½ W, 5%, P/N10011-222, AB, Mfr. P/N EN2225. C111 to – Same as C4 Add C112 – 10 F, 35 V, P/N11512-106, TI, Mfr. P/N SCM106GP035B2. CR131 to – HPA2900, P/N12224-001, HP, Mfr. P/N HPA2900. Change quantity of CR1 to 35. Add Q11 – Same as Q1. Section 5.4 Pulse Width Switch Assembly – Change C91, P/N11027-531 to P/N11027-431.
3664	11-3-71	37001-153 40000-480	Change CR501 through CR504 from DP19-1, 1N4002, P/N22194-001 to 1N4005, P/N12194-005.

WARRANTY

The Datapulse Division, Systron-Donner Corporation (hereinafter referred to as Datapulse) warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, transistors, fuses or batteries which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been thus defective.

Instruments returned under this Warranty will not be accepted at the Datapulse plant without prior authorization by a Datapulse representative or by the service manager of Datapulse.

Datapulse reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Datapulse and Datapulse neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Datapulse instruments.

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